GENERAL LIBRARY
SCIENCE LIBRARY
JUL 13 1919
UNIV. OF MICH.

BIOLOGICAL BULLETIN

OF THE

Marine Biological Laboratory

WOODS HOLE, MASS.

VOL. XXXVI MAY, 1919 No. 5

CONTENTS

		PAGE
YOUNG, R. T.	*The Degeneration of Folk Glands and Cells in Cestodes*	309
" "	*Association of Somatic and Germ Cells in Cestodes*	312
FAUST, ERNEST CARROLL.	*The Excretory System in Digenea, I.*	315
" " "	*The Excretory System in Digenea, II.*	322
" " "	*The Excretory System in Digenea, III.*	340
Twenty-First Annual Report of the Marine Biological Laboratory for the Year 1918.		345

PUBLISHED MONTHLY BY THE
MARINE BIOLOGICAL LABORATORY

PRINTED AND ISSUED BY
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

AGENT FOR GREAT BRITAIN
WILLIAM WESLEY & SON
28 Essex Street, Strand, London, W. C.

Single Numbers, 75 Cents. Per Volume (6 numbers), $3.00

Entered October 10, 1902, at Lancaster, Pa., as second-class matter under Act of Congress of July 16, 1894.

Editorial Staff

E. G. Conklin—*Princeton University.*

George T. Moore—*The Missouri Botanic Garden.*

T. H. Morgan—*Columbia University.*

W. M. Wheeler—*Harvard University.*

E. B. Wilson—*Columbia University.*

Managing Editor

Frank R. Lillie—*The University of Chicago.*

All communications and manuscripts should be sent to the Managing Editor, the University of Chicago, Sept. 15th to June 15th, or Woods Hole, Mass., June 15th to Sept. 15th. Subscriptions and other matter should be addressed to the Biological Bulletin, 41 North Queen Street, Lancaster, Pa.

Vol. XXXVI. *May, 1919.* *No. 5.*

BIOLOGICAL BULLETIN

THE DEGENERATION OF YOLK GLANDS AND CELLS IN CESTODES.

R. T. YOUNG.

Yolk glands, while frequent, are not of universal occurrence in flat worms, nor do they apparently bear any constant relation to the systematic position of the various groups of this phylum. In the Acœla, which are probably to be regarded as the most primitive of the latter, they are lacking, with the exception of *Polychœrus*, while the same is true of the polyclads, which are one of the more specialized of these groups.[1]

Among trematodes they are universally present with the exception of *Gyrodactylus*, where their absence is possibly correlated to the peculiar mode of reproduction, while in cestodes they are typically present, though reduced in some and in one case at least absent.

Braun[2] in his description of the yolk glands in this class has pointed out their gradual reduction in size from those such as *Tetrarhynchus tetrabothrius*, in which the gland forms a mantel around the entire proglottid, to those such as many Tæniæ, where the gland is reduced to a small unpaired organ adjacent to the ovary. It is this reduction of yolk glands in some cestodes, together with certain corollaries deducible therefrom, that I wish to discuss briefly in this note.

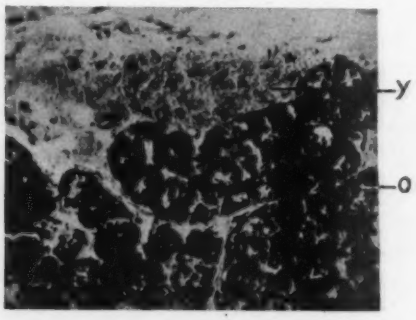
In a study of gametogenesis in cestodes upon which I am

[1] This last statement holds good even though the polyclads be considered as directly derived from the ancestral form. If the Acœla however be regarded as degenerate, rather than primitive types, then the absence of a yolk gland here may be attributed to such degeneracy. This would not explain their presence in *Polychœrus* however, nor their absence in *Gyrodactylus*, which is exceptional among trematodes in this respect.

[2] Braun, M., "Cestodes" in Braun's Kl. and Ord. IV., Ib.

engaged, I have examined the reproductive apparatus of a number of species, in one of which I am unable to discover a yolk gland, while in another I find evidence of its degeneration. The species in which this organ is evidently lacking is *Thysanosoma actinoides*. A yolk gland in this species was described by Stiles and Hassall in 1893.[1] Their work was done, however, on material which they expressly state was in such poor condition that many details could not be worked out. In a study of the reproductive organs in this form Swingle[2] was unable to find a yolk gland, nor can I do so. Therefore I believe that the former authors were misled, mistaking possibly a posterior lobe of the ovary for a yolk gland.

In *Hymenolepis* sp., I find evidence of the degeneration of



Yolk gland (*Y*) and ovary (*O*) of *Hymenolepis* sp. × 500.

the yolk gland, for here not only is the gland reduced in size, but it contains no yolk. Yolk takes iron hæmatoxylin with avidity, so that if present in the yolk cells it should appear with this stain, as it does very clearly in the ovary, whose cells are heavily laden with it. In the figure is brought out very clearly the distinction between the yolk filled ova and the empty yolk cells. This is true at least of later stages of the gland. In earlier stages the densely crowded and heavily staining nuclei

[1] Stiles, C. W., and Hassall, A., "A Revision of the Adult Cestodes of Cattle, Sheep and Allied Animals," U. S. Dept. Agric., Bur. An. Ind., Bulletin No. 4.

[2] Swingle, L. D., "The Morphology of the Sheep Tapeworm, *Thysanosoma actinoides*," University of Wyoming, Agric. Exp. Station, Bulletin No. 102.

render it impossible to say that no yolk is present at this time. It is not evident at this time however nor is its presence to be expected in early stages of the yolk gland, before any considerable differentiation of its cells has taken place. The nucleus of the adult yolk cell apparently offers further evidence of degeneration for it is very irregular and broken in form and contains but little chromatin, though how much of this appearance is natural and how much artificial, due to imperfect action of the fixative on exceedingly plastic structures, I cannot say. In earlier stages however the yolk cell nuclei are fairly definite structures in similarly fixed material, so I incline to the belief that their irregular appearance in later stages is due to degeneration.

I have pointed out above that there is little constancy in the occurrence of a yolk gland in flat worms. It may exceptionally be present in some form in a group, where otherwise it is absent, and vice versa. The fact that it is almost certainly to be regarded as a specialized part of the ovary, and that its function may be largely assumed by the latter even when it is present, as in cestodes, reduces its functional importance and consequently its selective value, and may therefore increase its variability and render it more liable to degeneration.

In cestodes the function of the yolk gland has been largely supplanted by the ovary itself, and its absence in one, and apparent degeneration in another species may very likely be prophetic of its future degeneration in cestodes as a group, together with so many other organs.

A further point of interest in connection with these observations is the fact that in *Thysanosoma actinoides*, where a yolk-gland is absent, the cell so frequently attached to the ovum and embryo, which has been assumed by several writers to be a polar body, is likewise absent; which is a further argument to be added to those already presented by me[1] for considering this cell a yolk cell rather than a polar body.

[1] Young, R. T., "The Histogenesis of the Reproductive Organs of *Tænia pisiformis*," *Zool. Jahrb.*, XXXV., 355–418.

ASSOCIATION OF SOMATIC AND GERM CELLS IN CESTODES.

R. T. YOUNG.

The differentiated tissues of cestodes all arise from the parenchyma, primarily of the larva and secondarily of the adult. From this are formed the sex cells, there being no evidence whatever to indicate any specialized "germ path" or "germ cell determinants." One author[1] indeed has gone so far as to claim that specialized cells (muscle) may even be de- and redifferentiated to form germ cells.

How far these observations of Child are valid is open to question. His figures certainly give considerable support to his contention, but it is difficult to prove that any muscle directly contiguous to a developing testis is responsible for the origin of the latter, or that the testis represents its original myoblast. The contiguity may be accidental, and the parent muscle cell may lie at a different place and be separated from the muscle fibre by a considerable space, being connected to it by only a slender process. The occurrence of multinucleate myoblasts, some of which Child has figured and which I have occasionally found in my own slides, renders his interpretation reasonable, but by no means proves it.

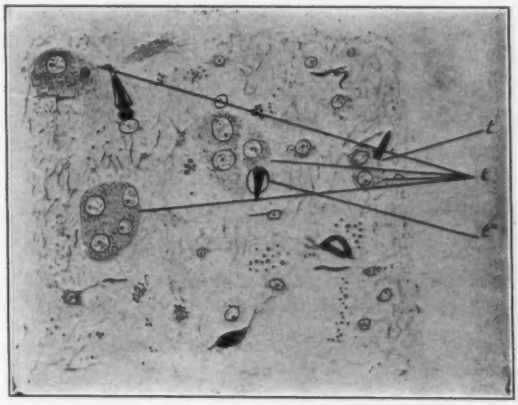
The occurrence of fully differentiated flame cells within the testis of several species[2] of cestodes, unconnected with any other flame cells or excretory capillaries is suggestive, although not proof of a common origin of these cells. It is quite possible that the flame cells may have arisen outside of the testis and migrated into the latter secondarily, or the testis and flame cell may have developed side by side, the latter becoming surrounded by the offspring of the former.

[1] Child, C. M., "Studies on the Relation between Amitosis and Mitosis, II., Development of the Testis and Spermatogenesis in *Moniesia*, BIOL. BULL., XII. 175–212.

[2] *Rhyncobothrium bulbifer*, *Dipylidium caninum* and an undetermined species from a woodpecker (*Dryobates*).

In the accompanying figure, however, I have shown what I consider good evidence in support of the former view.

This shows part of a proglottid of *Dipylidium caninum* containing numerous early testes. One of these contains but two cells, of which one is a developing flame cell (t') showing only the cone of cilia, while the other is a testis cell. Another shows



A part of the parenchyma of *Dipylidium caninum*, showing developing testes (t), two of which contain flame cells (t^1 and t^2), camera drawing. × 900.

several testis cells and one developed flame cell (t^2), which is not yet however connected with any capillary.

Obviously, I cannot prove that the groups containing t^1 and t^2 are developing testes. Their similarity of structure to neighboring testes is however sufficiently evident.

But whether or not these flame cells and the cells of the testes in which they lie are of common parentage, their occurrence within the testes is evidence of the simplicity of cestode development; for it shows that apparently any cell of one tissue (testis or parenchyma) may develop into a specialized cell of another tissue (flame cell) entirely apart from any other cells of the latter; the apparently determining factor being a stimulus of the physiological environment.

The question why two cells in close proximity to each other and probably of common descent, should develop on the one

hand into a flame cell, and on the other into a testis cell, cannot of course be answered in the present state of our knowledge. It is not unreasonable to suppose however that, as the result of some slight initial difference, one might become more susceptible to the presence of excreta in its environment and so develop into a flame cell; while the other, less susceptible to such influence, would follow its original course of development and become a testis cell.

There is in these cases evidently no continuity of development of the various parts of the excretory system as contended by Blochmann[1] and others, and discussed by me in an earlier paper.[2]

. Such facts further clearly argue against the Roux-Weismann theory of mosaic inheritance, and in favor of Driesch's view that developing cells are totipotent, so far at least as cestodes are concerned.

[1] Blochmann, F., "Die Epithelfrage bei Cestoden und Trematoden," Hamburg, 1896.

[2] Young, R. T., "The Histogenesis of *Cysticercus pisiformis*," Zoöl. Jahrb., XXVI., 183–254.

THE EXCRETORY SYSTEM IN DIGENEA. I.

ERNEST CARROLL FAUST.

NOTES ON THE EXCRETORY SYSTEM OF AN AMPHISTOME, *Cercaria convoluta*, NOV. SPEC.[1]

Recently the excretory system of certain distomes has been described. Sewall Wright (1912: 167–170) made a thorough study of the system in the adult *Microphallus opacus*. Cort (1918, 1918a) and the writer (1918, 1918a) have added to the knowledge of these organs in cercariæ and distomula. However, no significant work on the excretory organs of amphistomes has been published since the important monograph of Looss (1892) on *Diplodiscus subclavatus* (Rudolphi). During the past year the writer has been enabled to make a detailed study of the cercaria and parthenita of an undescribed amphistome for which the name *Cercaria convoluta* is proposed. Although the main purpose of this paper is to elucidate the excretory system of this amphistomulum, a brief description of the other organs is made as a matter of record.

Cercaria convoluta nov. spec.

Host: *Planorbis trivolvis* Say.
Parthenita: redia.
Habitat: Urbana, Illinois.
Date: April to November, 1918.
Systematic position: Diplodiscinae.

Cercaria convoluta is a pyriform larva, measuring from 0.4 to 0.76 mm. in length by 0.3 to 0.56 mm. in width. The tail is approximately twice as long as the body. The oral cavity has a maximum outer diameter of 0.1 mm. The acetabulum, situated at the posterior margin of the body, has a width diameter of 0.16 mm. and a length diameter of 0.12 mm. It is directed ventrad. The pharyngeal pockets are large and conspicuous.

[1] Contributions from the Zoölogical Laboratory of the University of Illinois, No. 130.

The esophagus is short; it is surrounded by a small bulbous pharynx just at the point where it opens into the diverticula. The latter extend caudad as far as the excretory pore and are usually undulatory in the adult larva. The genital organs are represented by four cell masses along the median line, suggesting ovary, testes and cirrus sac. Chords of cells run from the generative organs to the genital pore. Two large eye-spots are situated dorsad in the plane where the divericula originate. They are composed of oval "lenses" surrounded by a mass of melanoidin granules. Dense patches of granules entirely obscure this region. Cystogenous granules form dense aggregates in the connective tissue of the worm. On placing the fluke in water they are freely thrown out and soon dissolve to form a mucus cyst capsule. Meanwhile the tail is easily loosed from the body and cast aside. This species probably belongs to the subfamily Diplodiscinæ.

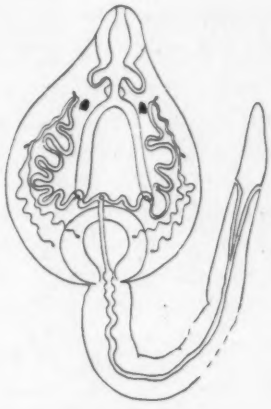
Cercaria convoluta develops within a redia with conspicuous "feet" and a large irregular pouch-like gut. The pharynx at the anterior end of the redia is small. An inconspicuous birth-pore is present. The redia may reach a length of 1.5 to 2 mm.

While the above description suffices to separate *Cercaria convoluta* from previously described cercariæ, this species is most strikingly delimited by the convolutions of the main excretory tubules of the cercaria. The excretory pore is located just in front of the anterior margin of the acetabulum. It is surrounded by a strong sphincter, and opens into a small bladder. From the latter organ a single median longitudinal canal runs caudad for about two-thirds the length of the tail. It then bifurcates, each fork opening to the exterior in the distal fifth of the tail. Immediately in front of the bladder is a horizontal collecting tubule which receives the excretory products from right and left sides. As this tubule reaches the sides of the acetabulum it is directed forward. In the very young cercaria it has a serpentine course. This tendency becomes progressively more pronounced as the larva develops, until in the mature cercaria it consists of a spiral of about six definite loops. At the place where the lateral collecting tubule reaches the eye-spot it reflexes outward and backward. Its course may be traced to the region of the bladder where it runs into the acetabulum. The posterior limit of the

main collecting tubule of each side is marked by a bifurcation. The outer (posterior) fork remains free, but the inner (anterior) one joins its mate of the opposite side and thus secures a physiologically important connection between the excretory courses of the two sides of the body.

The flame cells have been carefully studied in living flukes. In the mature cercaria they are naturally divided into three

1



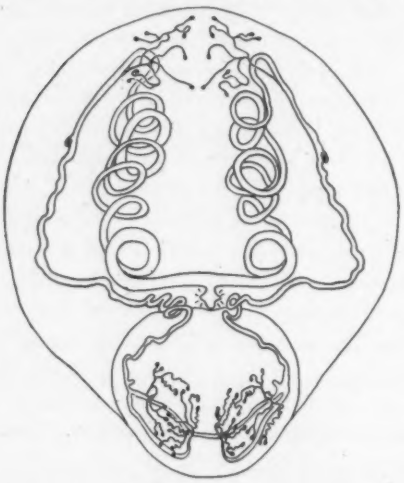
2

FIG. 1. Very young *Cercaria convoluta*, showing three flame cells on each side of the body. × 250.

FIG. 2. Four cell stage in development of excretory system of *C. convoluta*. × 225.

groups. At the anterior end, given off just after the collecting tubule flexes caudad, there is a cluster of eight cells on each side of the body. Midway down on the reflexed portion of the tubule a single large flame cell is found. In the acetabulum the outer (posterior) tubule of the posteriormost group terminates in a cluster of eight cells. The inner (anterior) likewise gives rise to a cluster of eight terminal flame cells. Analysis shows that the cephalic group of eight cells and the two octet groups in the acetabulum all have an orderly arrangement and are the result of a regular development. Each consists of a quadruple bifurcation of an originally single flame cell. Moreover, this analysis is borne out by the successive stages in the development of the system. The collecting system is originally composed

of a single pair of tubules. Fusion of these two canals occurs at an early stage in the region of the bladder and anterior part of the tail. When the pigmentation of the eye-spots first becomes conspicuous three groups of flame cells are already present, each group being represented by a single cell (Fig. 1). Later, when the animal assumes a more characteristic shape (Fig. 2), the posteriormost cell and tip of the tubule has bifurcated. With the maturing of the cercaria successive stages of division of the anteriormost flame cell into two, four and eight cells may be found. The middle cell remains single, which fact accounts for



3

4

FIG. 3. Mature *Cercaria convoluta*, with 25 flame cells on each side of the body. × 175.

FIG. 4. Excretory system in the parthenita of *C. convoluta*. × 175.

its disproportionately large size. In the posteriormost group the main canal of the inner (anterior) tubule approaches its mate of the opposite side and fuses with it. The cell becomes oriented laterally and gives rise to eight cells. In like manner the outer (posterior) tubule produces eight flame cells near its median margin. Thus there are formed (Fig. 3) twenty-five flame cells on each side of the body of the mature *Cercaria convoluta* from three original groups of one flame cell each.

Proof of the fundamental character of the groups and numbers of flame cells in *Cercaria convoluta* is further established by the analysis of the excretory system of the redia. Here (Fig. 4) there are three groups of flame cells on each side of the body, although the more primitive character of the redia is evidenced by the single cell as representative of each group.

Discussion.

The exact knowledge of the groups of flame cells and exact grouping of these cells in *Cercaria convoluta* makes it possible to understand the importance of the excretory system both in the anatomy and systematology of the group. In his study of *Diplodiscus subclavatus* Looss has shown that the miracidium of his species has a single pair of flame cells at the anterior end of the unbranched collecting tubules. With the metamorphosis into a sporocyst the collecting tubules elongate but the single flame cell on each side persists. In the redia of this species Looss has found from two to four flame cells on each side of the

Table I.

Showing Number of Flame Cells Respectively in Cercaria convoluta and C. diplodisci subclavati at various stages in the Life History.

	Miracidium.	Sporocyst.	Redia.	Cercaria.				Mature Worm.
				Stage 1.	Stage 2.	Stage 3.	Stage 4.	
C. convoluta ..	?	?	3	1	1+1+1	1+1+1+1	8+1+8+8	?
C. diplodisci subclavati...	1	1	4 (?)	1	1+1+1+1	omitted	3+2+2+8 (9)	?

median line, although he is not sure if the number is constant. In the writer's species there are always three flame cells on each side of the redia. In the cercaria germ-ball in both *C. diplodisci subclavati* and *C. convoluta* there is at first a single flame cell for each lateral collecting tubule. The next stage recognized by Looss in his species is one with four flame cells, each of which appears to represent a separate group. A subsequent stage in Looss's figures shows three cells for the cephalic group, two each for the two groups in the middle of the body and eight (or nine) for the acetabular group. This same number persists in the

mature cercaria. In *Cercaria convoluta*, on the other hand, a distinct three-cell stage is passed through. The four-cell stage is found only after the acetabular cell has divided. Then by successive divisions eight cells are formed from the cephalic and each of the acetabular groups, while the cell in the mid region of the body fails to divide. Thus in the mature cercaria of *Diplodiscus subclavatus* there are fifteen or sixteen flame cells on each side of the body while in the writer's species twenty five flame cells have been consistently found.

In spite of the less pronounced symmetry of division of flame cells in *Cercaria diplodisci subclavati* it is nevertheless highly probable that the grouping is of a fourfold character both in redia and cercaria, just as the arrangement in *C. convoluta* is threefold. Thus within a relatively small subfamily there exists a fundamental difference of arrangement of a relatively conservative system.

Summary.

1. *Cercaria convoluta*, a new species belonging to the Diplodiscinæ, is described.

2. The development of flame cells in both redia and cercaria of this species is based on a three-fold division of a primitively single flame cell on each side of the body.

3. A study of the development of flame cells in *C. diplodisci subclavati*, based on Looss's study, shows a four-fold group arrangement but with less exact symmetry.

4. A comparison of these two forms shows a fundamental difference of arrangement of a relatively conservative system within the same subfamily.

References Cited.

Cort, W. W.

'18 Homologies of the Excretory System of the Forked-Tailed Cercariae. Jour. Parasit., 4, 49–57.

'18a The Excretory System of *Agamodistomum Marcianae* (La Rue), the Agamodistome Stage of a Forked-Tailed Cercaria. Jour. Parasit., 4, 130–134.

Faust, E. C.

'18 Life History Studies on Montana Trematodes. Ill. Biol. Monogr., 4, 1–120, 9 pl.

'18a Studies on Illinois Cercariae. Jour. Parasit., 4, 93–110, 2 pl.

Looss, A.
'92 Recherches, sur la Faune Parasitaire de l'Égypte, prem. partie. Mem. Inst. Égypt., 3, 1–252, 15 pl.
Wright, Sewall
'12 Notes on the Anatomy of the Trematode, Microphallus Opacus. Trans. Am. Micr. Soc., 31, 167–175, 2 pl.

THE EXCRETORY SYSTEM IN DIGENEA. II.

ERNEST CARROLL FAUST.

Observations on the Excretory System in Distome Cercariæ.[1]

The diverse groups connoted by the term "distome cercariae" are found to be decidedly heterogeneous when the reproductive and excretory systems are examined. Even the nervous system is extraordinarily modified in one family of this group, the Schistosomatidæ. Students of distome cercariae have commonly made mention of the bladder and have frequently observed the main collecting tubules of the excretory system. Only infrequently, however, have they traced out accurately the auxiliary tubules and made an exact analysis of the flame cells at the distal ends of the capillaries. Even as accurate an observer as Looss has often been unable to analyze the system in material which was available for study as living mounts. Failure to determine the number of flame cells and their exact relationship to the collecting tubules may be due to (1) paucity of material at hand, (2) concealment of the cells by cystogenous or mucin glands or heavy and spinose integument, or (3) insufficient time to make careful observations at the exact moment when the material is best fitted for study. In general, mature free-swimming cercariæ are much the best for this study and freshly dissected material is much better to work on than that which has been standing for several hours. It is true, however, that material may present seemingly insuperable difficulties for the study of the excretory system at a certain time or when taken from a certain place, while at another time or in another locality the study of the same species may be one of comparative ease.

Cort has frequently noted that the study of the excretory system is both tedious and wearisome. The writer may add that a successful analysis of the system requires greater care and more poise of judgment than that of any other system of the fluke.

[1] Contributions from the Zoölogical Laboratory of the University of Illinois, No. 131.

It is the purpose of this paper to present data on the excretory system of three distinct groups of distome cercariæ, the echinostome cercariæ, the xiphidiocercariæ and the furco-cercariæ, and to show how these data may be used to supplement the anatomical relationships based on other fundamental systems of these platodes.

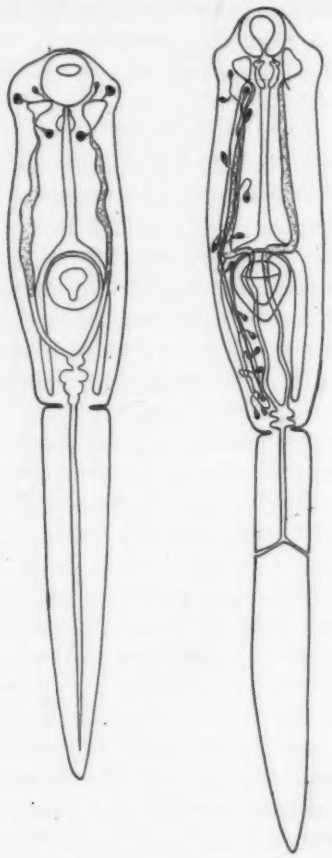
Echinostome Cercariæ.

These cercariæ, frequently designated as the offspring of rediæ, with a collar of spines at the anterior end of the body, may be as readily recognized by the pair of heavy collecting tubules extending from the bladder to the region of the pharynx, where they become constricted and reflex on themselves in triangular fashion (see Figs. 1 and 2). The manner in which the flame cells are disposed, together with their number, and the course of the tubule in the tail offer a method for separating larval echinostomes into two quite distinct groups.

The more simple of these groups, as illustrated in Fig. 1, shows the collecting tubule ending in the triangular flexure and only three flame cells for each half of the body. The cells are situated at the ends of small capillaries which empty, the one at the end, the others at the sides of the triangle. No other flame cells occur along the entire course of the tubules. In the tail a single median tubule runs from the distal end forward into the bladder. Of the cercariæ in which the flame-cell count has been satisfactorily worked out, two species fall into this group, *Cercaria chisolenata* Faust, 1918, and *C. trisolenata* Faust, 1917.

The second or more complex type is one in which the constricted tubule does not end in the region of the triangular flexure lateral to the pharynx but continues caudad to the posterior region of the body. Commonly (Fig. 2), when this secondary portion of the tubule reaches the posterior region of the body, it bends forward and continues to the region of the pharynx. Numerous flame cells, constant for each species, are connected by minute capillaries with this tertiary portion of the tubule. In *Cercaria acanthostoma* Faust, 1918, sixteen flame cells occur along each tubule. In *Cercaria complexa* nov. spec. the number is fifteen. In this type also the main collecting tubule of the tail, after coursing distad for a short distance, bifurcates and opens on each side through a simple pore. To this type belong *C. trivolvis* Cort

and *C. reflexae* Cort in which the flame cells have not been worked out. The cercaria of *Echinostomum revolutum* (Froel.) is also a



1 2

FIG. 1. *Cercaria chisolenata* Faust, ventral view, showing excretory and digestive systems. × 105.

FIG. 2. *Cercaria complexa* nov. spec., ventral view, showing excretory and digestive systems. × 170.

member of this group but is not entirely typical, for in this species the tertiary portion of the collecting tubule arises as a bifurcating branch from the mid-region of the secondary portion of the canal. Flame cells occur along both rami of the tertiary

tubule and probably also along the posterior part of the secondary tubule. The exact number of flame cells for each side of the body is not clearly shown but somewhere between eighteen and twenty may be counted (Looss, 1894: Fig. 191).

A species showing relationships intermediate between these two groups is *Cercaria biflexa* Faust, 1917. Both secondary and tertiary portions of the tubule occur here (Faust, 1918, Fig. 138), but they are confined entirely to the head region of the body. Numbers of tributaries to the primary tubule (Faust, 1918, Fig. 135) empty into that canal but no flame cells have been found in connection with them. In the tail of this species the main collecting tubule forks about two-fifths the way distad. The forks continue to the end of the tail but have not been found to end in pores to the exterior. Numerous branches empty into the single and bifurcated portions of the canal.

In the matter of origin the species with three flame cells in the anterior and of the worm are undoubtedly the simpler. It is not improbable that the three anteriormost flame cells of the more complex type are homologous to the three cells of the simpler type. This theory is supported by the evidence from *C. biflexa*, which, with the flexures similar to *C. complexa*, has the flame cells of the anteriormost portion of the tertiary tubule.

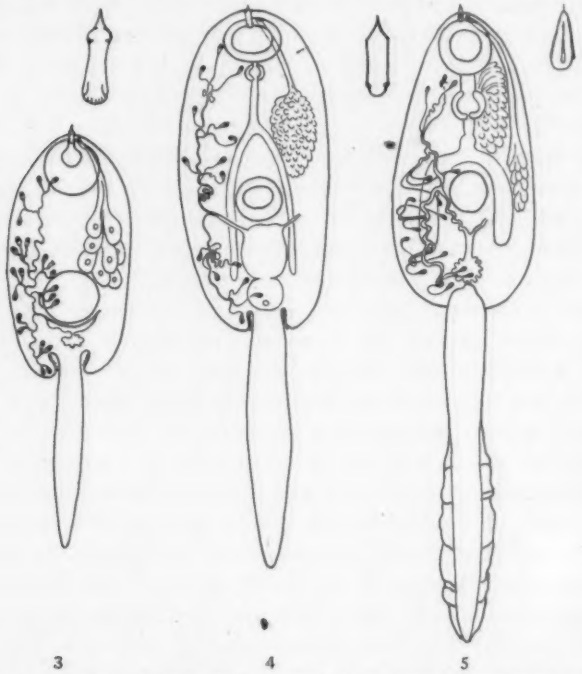
In view of the relationship existing among these species it seems feasible to classify them in groups on the basis of a *flame-cell formula*. Thus the flame-cell formula of *Cercaria chisolenata*, *C. trisolenata* and *C. biflexa* is 3, that of *C. complexa* is 15 = (3 + 12), and that of *C. acanthostoma* is 16 = (3 + 13). Further study of the flame cells in larval echinostomes will probably furnish evidence of other types and many other points of fundamental interest.

Xiphidiocercariæ.

Anatomically the xiphidiocercariæ have little in common. Each species quite probably has a distinct type of stylet but no satisfactory classification is likely to result on the basis of this larval piercing organ. Likewise the genital and excretory systems show very great differentiation. The writer (1918, 38–40) has shown and described some of the fundamental types of bladder and main collecting tubules of this group. Ordinarily

the collecting tubules arrange themselves in anterior and posterior branches.

The first xiphidiocercaria in which the writer was able to make an analysis of the number and relation of flame cells was *Cercaria isocotylea* Cort (Faust, 1918a; also Fig. 3, this paper).



3 4 5

FIG. 3. *Cercaria isocotylea* Cort, ventral view, showing excretory system and mucin glands. × 170. 3*a*, stylet, × 540.

FIG. 4. *Cercaria candelabra* nov. spec., ventral view, showing excretory and digestive systems. × 170. 4*a*, stylet, × 540.

FIG. 5. *Cercaria trifurcata* nov. spec., ventral view, showing excretory and digestive systems. × 105. 5*a*, stylet, × 540.

The number of flame cells is large for a cercaria and the arrangement is complex. Placing the cells of this species into anterior and posterior groups respectively, the flame-cell formula is

$$22 = ([2 + 2 + 3 + 3 + 3 + 3] + [2 + 2 + 2]).$$

More recently the writer has studied the excretory system in two xiphidiocercariæ, also from Urbana, Illinois, *C. trifurcata*

nov. spec., and *C. candelabra* nov. spec., both with an equal number of flame cells and with the same number to the group, but with a different disposition of the groups anteriad and posteriad. Thus the flame-cell formula of *C. trifurcata* is 15 = ([3 + 3] + [3 + 3 + 3]), while that of *C. candelabra* is 15 = ([3 + 3 + 3] + [3 + 3]).

Although these three species constitute the only known xiphidio-cercariæ in which the flame-cell number and grouping have been worked out to a certainty, very considerable light is thrown on the subject by a comparison of these larval species with related adult species. *Allocreadium isoporum* (Looss, 1894, Fig. 103) has a flame-cell formula of 24 = ([4 + 4 + 4 + 4] + [4 + 4]). The larva is a stylet cercaria with an unusually large tail. The larva of *Acrolichanus petalosa*, belonging to the same family, has the same fundamental flame-cell grouping but reversed as regards number of units disposed anteriad and posteriad. The formula is 12 = ([2 + 2] + [2 + 2 + 2 + 2]). *Anchitrema sanguineum* (Looss, 1896, Fig. 77) has a flame-cell formula of the same number of groups but different disposition of the groups and different numbers of cells within the groups, *i. e.*, 16 = ([2 + 3 + 3] + [3 + 3 + 2]).

Two plagiorchiine species, *Haplometra cylindracea* and *Opistoglyphe endolobum* (Looss, 1894, Figs. 29, 163) have larvae which are typically xiphidiocercariæ. Both of these adult species have the same flame-cell formula, 18 = ([3 + 3 + 3] + [3 + 3 + 3]). The very young distomulum of *Opistoglyphe* has a formula of 6 = ([1 + 1 + 1] + [1 + 1 + 1]), from which it is plainly to be seen that the adult condition is derived by a triad splitting of each fundamental group. That species in two different subfamilies of the Plagiorchiidæ should have identical flame-cell formulæ is quite significant.

Again, certain subfamilies of the Brachycœliidæ, in which the larvae are thought to be xiphidiocercariæ, have a flame-cell formula of 12 = ([3 + 3] + [3 + 3]), while *Microphallus opacus* (Wright, 1912), belonging to another subfamily of the Brachycœliidæ, has a formula of 8 = ([2 + 2] + [2 + 2]). Analysis shows that these two species have a *common larval denominator*, namely 4 = ([1 + 1] + [1 + 1]). In other words, the mathematical exactness of flame-cell formation in this family makes it

possible to calculate the flame-cell formula of the cercaria from the condition of the adult.

The study of the flame-cell structure in the xiphidiocercariæ and comparison of the system with that of the related adult flukes show in the first place that the fundamental basis of the system is the number and disposition of the flame-cell groups. Knowledge of the structure of the excretory system in the Plagiorchiidæ and Brachycœliidæ makes it possible to state that this fundament in these groups is a family or subfamily character. The number of flame cells in each basic group is of lesser importance. Thus in the plagiorchiine species, where the species is known, triad groups are the rule, but in the brachycœliine species diad formation occurs in one subfamily and triad formation in another. In the second place this study has caused the writer to believe that this system is decidedly conservative in the xiphidiocercariæ.

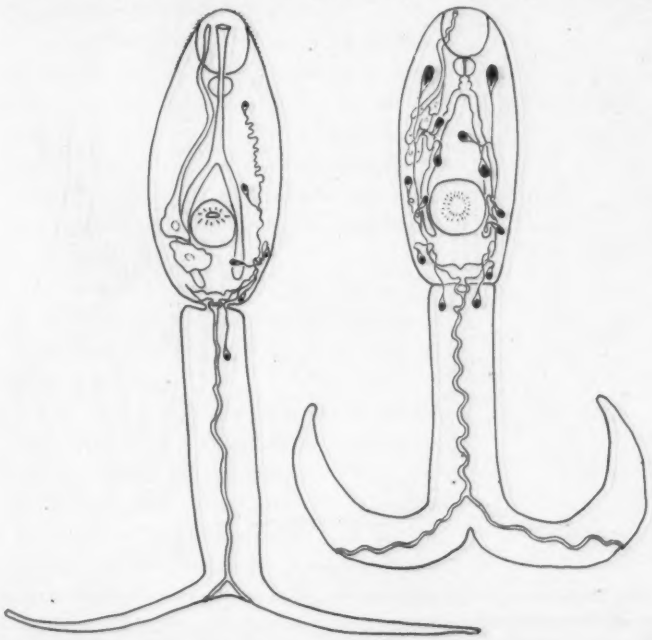
A study of *Cercaria trifurcata* and *C. candelabra* shows these species to have a flame-cell formula intermediate in form between that of the Brachycœliidæ and the Plagiorchiidæ. *C. trifurcata* represents a type in which the anterior fundament is brachycœliine and the posterior fundament plagiorchiine, while *C. candelabra* represents just the reversed condition. On account of the large number of flame cells already present in the larva it is highly probable that both of these species represent a condition of flame-cell development which for the cercaria is somewhat more precocious than that of the larvæ of the Brachycœliidæ and the Plagiorchiidæ. The system in *C. isocotylea* has reached a high degree of complexity which bears homologous relationships to no other known system in larval or adult flukes.

Furcocercariæ.

The forked-tailed cercariæ have secured more than ordinary attention during the past few years because experimental evidence has shown some of them to have a genetic relationship to the three human blood flukes, *Schistosoma hæmatobium*, *S. mansoni* and *S. japonicum*. Cort (1918)has made a careful analysis of the excretory systems in five furcocercariæ and the writer (1918a) has previously published flame-cell data for the species *C. gigas*. The writer's study of four additional species tends both to con-

firm Cort's data and, in supplementing and expanding these data, to emphasize the writer's previous view (1918a, 108) that it seems "reasonable to recognize a complete series of larva forms from those with a pharynx sphincter . . . to the human schistosome cercariæ."

Of the ten species of forked-tailed cercariæ for which adequate data are at hand with respect to the flame-cell structure, the cercaria of *Schistosoma japonicum* presents the most simple basic plan. Following the method previously used in this paper, the flame-cell formula of this species is $4 = (2 + 2)$. That one



6 7

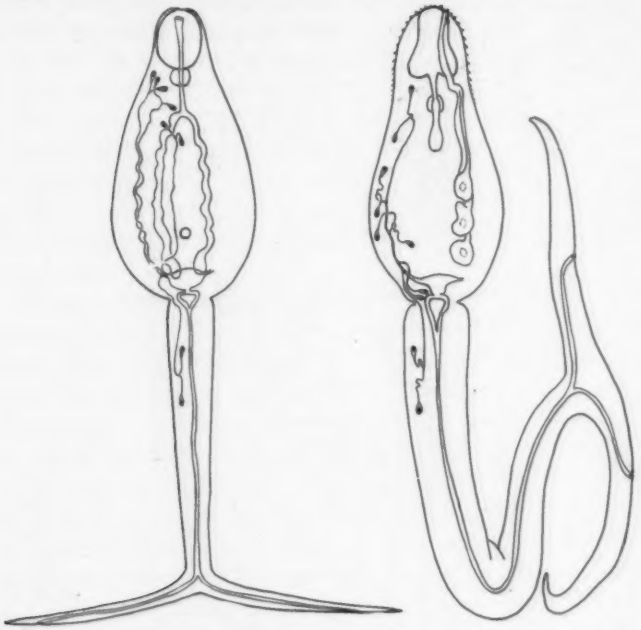
FIG. 6. *Cercaria furcicauda* nov. spec., ventral view, showing excretory and digestive systems. × 170.

FIG. 7. *Cercaria robusticauda* nov. spec., ventral view, showing excretory and digestive systems. × 540.

of these flame cells in each lateral circuit is found in the caudal portion of the larva is incidental rather than fundamental. The species *Cercaria douthitti* and *C. elephantis* of Cort represent

a type with a slightly more complex formula, $6 = (3 + 3)$. The fundament is, however, just the same, $2 = (1 + 1)$, so that these two may be considered two subdivisions of one larger group, all members of which have the same basic formula.

A simple condition of a stage in advance of this primitive group cited above is expressed in the excretory system of *Cercaria furcicauda* nov. spec. (Fig. 6), in which there are three



8 9

FIG. 8. *Cercaria quatluor-solenata* nov. spec., ventral view, showing excretory and digestive systems. × 105.

FIG. 9. *Cercaria rhabdocaeca* nov. spec., ventral view, showing excretory and digestive systems. × 330.

instead of two basic groups. The formula for the flame cells in this species is $6 = (2 + 2 + 2)$. One of these flame cells is in the tail. Two species, evidently differing in minor characters but bound together by the same number and arrangement of flame cells are *C. emarginatæ* and *C. douglasi*. These differ from

C. furcicauda in having three flame cells instead of two in the first (anterior) group. The formula for these species is $7 = (3 + 2 + 2)$. In *Cercaria robusticauda* (Fig. 7) there are the same number of flame cells as in *C. emarginatæ* and *C. douglasi*, but the size of the anteriormost is evident proof of its double nature. Hence the formula for this species is $7 = (1 + 2 + 2 + 2)$. One of these cells runs into the tail. This species is transitional between the larvæ with seven flame cells in three groups and *C. quattuor-solenata* nov. spec.

C. quattuor-solenata (Fig. 8) represents a condition in which a full additional flame-cell unit has been provided. Its formula is $8 = (2 + 2 + 2 + 2)$. Incidentally, the main collecting tubule in this species has been shortened to a minimum, while the four secondary tubules have been lengthened accordingly.

In *Cercaria rhabdocæca* nov. spec. (Fig. 9) five fundamental flame-cell groups are found, so that the formula is $10 = (2 + 2 + 2 + 2 + 2)$.

The flame-cell arrangement in *Cercaria gigas* (Fig. 10) is apparently unrelated to any of the foregoing species. Ten flame cells have been found on each side of the body of the cercaria and one in the tail. By inspection the formula would seem to be $10 = (2 + 1 + 1 + 1 + 1 + 3 + 1)$. That this may constitute a seven-fold grouping, in which two of the groups have divided, is supported in part by the fact that the single cells are somewhat larger than the cells of the units where the division has taken place, but the evidence is not entirely convincing. In the mature cercaria of this species the flame cell in the tail has no direct connection with the cells or tubules of the body proper. Its outlet is through a simple longitudinal

FIG. 10. *Cercaria gigas* Faust, dorsal view, showing excretory system on right side of body. × 540.

vessel which empties into the bladder at the side of the median collecting tubule of the tail, just behind *the island of Cort.*

In all of these furcocercariæ, as well as in others where the flame cells have not been worked out, there is a forking of the caudal excretory tubule at the junction of furci with tail trunk. The forked tubules empty through simple pores at the sides or distal extremity of the tail-furci. Comparison of the point of opening of these pores in various species shows that in the cercaria of *Schistosoma japonicum*, *C. douthitti* and *C. elephantis* the openings are at the tips of the furci; that in most other forms they are half-way out on the sides; but that in *C. furcicauda* the outlets are near the origin of the furci (Fig. 6). Thus the writer sees no consistent correlation between the flame-cell formulæ and the point of outlet of the caudal tubules.

In furcocercariæ the excretory system is apparently always provided with *the island of Cort.*

Analysis of the flame-cell fundaments in this group shows a simple basic plan and an unusually complete series of stages from the simplest combination of units (cercaria of *S. japonicum*)

TABLE 1.

METHODS FOR DISTINGUISHING THE BETTER KNOWN FORKED-TAILED CERCARIÆ.

Species.	Flame-cell Formula.	Digestive Tract.	Eye-spots.
Cercaria of *Schistosoma japonicum*.....	4=(2+2)	pharynx absent, 5 pairs mucin glands.	absent.
Cercaria douthitti.....	6=(3+3)	pharynx absent, 5 pairs mucin glands.	present.
Cercaria elephantis.....	6=(3+3)	pharynx absent, 25–30 pairs mucin glands.	present.
Cercaria furcicauda.....	6=(2+2+2)	pharynx present, 2 pairs mucin glands.	absent.
Cercaria emarginatæ.....	7=(3+2+2)	pharynx present, mucin glands?	absent.
Cercaria douglasi.....	7=(3+2+2)	pharynx present, 2 pairs mucin glands.	absent.
Cercaria robusticauda...	7=(1+2+2+2)	pharynx glandular, 6 pairs mucin glands.	absent.
Cercaria quattuor-solenata.....	8=(2+2+2+2)	pharynx present, no mucin glands.	absent
Cercaria rhabdocæca....	10=(2+2+2+2+2)	pharynx present, rhabdocœl gut, 3 pairs mucin glands.	absent.
Cercaria gigas.....	10=(2+1+1+1+1+3+1) (?)	pharynx absent, mucin glands many, of two kinds.	present.

to a rather large aggregate of such units (*C. rhabdocœca*). *C. gigas* is apparently not related to this series, since an analysis of its flame cells fails to show any direct correlation with the established series.

Discussion.

The data presented in this paper are of fundamental significance in establishing the relationships of various larval flukes to one another and of larvæ to adults. Present knowledge not only preponderates in favor of the view that the number of flame cells in the species is constant, but establishes the belief also that the same basic number and arrangement of flame cells exist within families or subfamilies. When once the number and disposition of flame cells has been established for a particular group it will be possible to predict the flame-cell formula of the larvæ. Thus a larva to belong to the Schistosomatidæ *sensu stricto* should possess a flame-cell arrangement consistent with the *common denominator* which the apharyngeal species of furcocercariæ possess in common, namely $2 = (1 + 1)$; and a plagiorchiine species should have the common formula of that family, $6 = ([1 + 1 + 1] + [1 + 1 + 1])$; and brachycœliine species should follow the scheme $4 = ([1 + 1] + [1 + 1])$. This accords with Cort's thesis on the conservatism of the excretory system, but it suggests, from the number of types already known, a larger number of possibilities of flame-cell arrangement than had been previously anticipated, and, accordingly, a larger number of family groups than the present knowledge of adult flukes postulates.

Because the number of basic groups is the most significant point in the analysis of the flame-cell arrangement of cercariæ and adults alike, there is justification for presenting general formulæ of flame-cell units which will apply equally well to all species of the same group. These formulæ are readily obtained if the *common denominator* of the species of the same group is taken and literal equivalents substituted for the numbers involved. Thus for the species of Schistosomatidæ the formula would read $\alpha + \beta$; for Brachycœliidæ $\alpha' + \beta' + \alpha'' + \beta''$, where the primed letters represent the anterior groups and the double-primed letters represent the posterior groups. Under

this scheme the echinostome larvæ with three flame cells on a side are given the formula of α, while those with other flame cells distributed along the tertiary collecting tubule behind the α group would be designated as $\alpha + \beta^n$. The full scheme for litteral formulæ for the larval and adult flukes where the flame cells have been best analyzed is presented in the following table (Table II.).

TABLE II.

GENERAL FORMULÆ FOR FLAME-CELL ARRANGEMENT IN DISTOMATA.

ECHINOSTOMES.	
Cercaria chisolenata, *Cercaria trisolenata*, *Cercaria biflexa*	α
Cercaria complexa, *Cercaria acanthostoma*	$\alpha + \beta^n$
XIPHIDIOCERCARIÆ.	
Cercaria trifurcata	$\alpha' + \beta' + \alpha'' + \beta'' + \gamma''$
Cercaria candelabra	$\alpha' + \beta' + \gamma' + \alpha'' + \beta''$
Cercaria isocotylea	$\alpha' + \beta' + \gamma' + \vartheta' + \epsilon' + \xi' + \alpha'' + \beta'' + \gamma''$
BRACHYCŒLIIDÆ	$\alpha' + \beta' + \alpha'' + \beta''$
PLAGIORCHIIDÆ	$\alpha' + \beta' + \gamma' + \alpha'' + \beta'' + \gamma''$
ALLOCREADIIDÆ.	
Allocreadium isoporum	$\alpha' + \beta' + \gamma' + \vartheta' + \alpha'' + \beta''$
Acrolichanus petalosa	$\alpha' + \beta' + \alpha'' + \beta'' + \gamma'' + \varphi''$
FURCOCERCARIÆ.	
Cercaria of Schistosoma japonicum, *Cercaria douthitti*, *Cercaria elephantis*	$\alpha + \beta$
Cercaria furcicauda, *Cercaria emarginatæ*, *Cercaria douglasi*	$\alpha + \beta + \gamma$
Cercaria robusticauda, *Cercaria quattuor-solenata*	$\alpha + \beta + \gamma + \vartheta$
Cercaria rhabdocæca	$\alpha + \beta + \gamma + \vartheta + \epsilon$

DESCRIPTION OF NEW SPECIES CITED IN THIS PAPER.

Cercaria complexa nov. spec. (Fig. 2.)

Systematic position: echinostome larva.

Parthenita: redia.

Host: *Planorbis trivolvis* Say.

Habitat and time of collection: drainage ditch, Urbana, Ill., 1918.

Flame-cell formula: $\alpha + \beta^8 = 3 + 12$ or 15.

Body 0.36 mm. long by 0.10 mm. wide; tail 0.36 mm. long by 35 μ in diameter at base. Oral sucker 35 μ in diameter, acetabulum 50 μ in diameter. Entire ventral surface of body between pharynx and acetabulum sunken into elongate bowl-like sucking organ. Collar spines 38, disposed in two alternating rows.

Redia with conspicuous "feet," rhabdocœl gut, collar prominence and birthpore.

Prepharynx short; pharynx urn-shaped; esophagus long, capillary; furci distended, extending to posterior tip of body. Mucin glands six, with ducts tipped with piercing spines.

Excretory tubules with double flexure; 15 flame cells along the entire length of the tertiary portion.

Cercaria trifurcata nov. spec. (Fig. 5.)

Systematic position: stylet larva.

Parthenita: sporocyst.

Host: *Physa gyrina* Say.

Habitat and time of collection: drainage ditch, Urbana, Ill., 1918.

Flame-cell formula: $\alpha' + \beta' + \alpha'' + \beta'' + \gamma'' = 3 + 3 + 3 + 3 + 3$ or 15.

Body 0.43 mm. long by 0.2 wide in region of acetabulum; tail 0.43 mm. long by 50 μ in diameter at base, fluted laterally in distal half. Entire body covered with minute spines.

Sporocyst consisting of elongate compound branches.

Acetabulum 60 μ in diameter; weak and ineffective; oral sucker 76 μ in diameter, directed anteriad. Prepharynx provided with great mass of secretory glands; pharynx and esophagus present but inconspicuous; ceca broad sacculate pouches extending some distance behind the acetabulum; mucin glands several, in vitiform cluster, with granular contents, emptying through long ducts at sides of stylet.

Bladder small, crenate; main collecting tubule Y-form; anterior collecting tubule of each half of body with two triplet groups of flame cells and posterior collecting tubule with three triplet groups of flame cells.

Cercaria candelabra nov. spec. (Fig. 4.)

Systematic position: stylet larva.
Parthenita: sporocyst.
Host: *Planorbis trivolvis* Say.
Habitat and time of collection: drainage ditch, Urbana, Ill., 1918.
Flame-cell formula: $\alpha' + \beta' + \gamma' + \alpha'' + \beta'' = 3 + 3 + 3 + 3 + 3$ or 15.

Body 0.25 mm. long by 0.09 mm. wide; tail two-thirds to three-fourths of body length. Integument heavy; body entirely covered with spines. Oral and ventral suckers 44 μ in diameter. Stylet in roof of oral sucker 25 μ long. Tail inserted into caudal pocket with a lateral pair of about ten heavy spines each.

Sporocyst simple, unbranched.

Prepharynx short; pharynx simple; glands crowding parenchyma emptying into pharynx; esophagus moderately long; ceca long, small, to subcaudal region of body. Mucin glands in vitiform clusters, antero-laterad to ceca, opening through long narrow ducts at sides of stylet.

Excretory bladder consisting of proximal and distal vesicles separated from one another by slightly muscular sphincter; collecting tubule emerging from each side of anterior vesicle with anterior tributaries from three triplet groups of flame cells and with posterior tributaries from two triad groups of flame cells.

Cercaria furcicauda nov. spec. (Fig. 6.)

Systematic position: furcocercous larva.
Parthenita: sporocyst.
Host: *Anculosa carinata* Brug.
Habitat and time of collection: Rome, Georgia, 1918.
Flame-cell formula: $\alpha + \beta + \gamma = 2 + 2 + 2$ or 6.

Forked-tailed cercaria with body 0.26 mm. long and 0.12 mm. wide; tail trunk equally long; furci two-thirds length of tail trunk, extending at right angles to trunk. Anterior region of body covered with minute spines. Oral sucker 48 μ in diameter, directed anteriad; acetabulum 40 μ in diameter, at beginning of posterior third of body. Eye-spots wanting.

Sporocyst simple, sausage-shaped sac.

Prepharynx and pharynx simple; esophagus moderately long; ceca typically furculate. Mucin glands two pairs, opening through long ducts at sides of oral atrium.

Excretory bladder small; collecting tubules swollen at base; three pairs of flame cells with capillaries opening into each collecting tubule, one flame cell of posterior couplet running back into tail.

Mass of germ cells just anterior to bladder.

Cercaria robusticauda nov. spec. (Fig. 7.)

Systematic position: furcocercous larva.

Parthenita: sporocyst.

Host: *Physa gyrina* Say.

Habitat and time of collection: drainage ditch, Urbana, Ill., 1918.

Flame-cell formula: $\alpha + \beta + \gamma + \vartheta = 1 + 2 + 2 + 2$ or 7.

Minute forked-tailed cercaria with body 75 μ in length by 25 μ in width, tail trunk equally long, but with short, stubby furci. Oral sucker 12 μ in diameter, directed forward; ventral sucker equal in diameter, somewhat back of middle of body, with two concentric rings of spines. Blunt spines covering anterior third of body. Eye-spots wanting. Morphological pharynx degenerate, with glandular instead of muscular cells; esophagus leading into furci which meander to posterior margin of acetabulum. Mucin glands about six on each side, homogeneous in character, opening through single ducts at each side of the oral aperture.

Excretory bladder bicornuate, with single collecting tubule running into cornu on each side. Flame cells based on four-unit plan, with a single cell in the anteriormost unit and a pair in each of the succeeding three.

Germ cells, consisting of a loose aggregate, in front of the bladder.

Cercaria quattuor-solenata nov. spec. (Fig. 8.)

Systematic position: furcocercous larva.

Parthenita: sporocyst.

Host: *Anculosa carinata* Brug.
Habitat and time of collection: Rome, Georgia, 1918.
Flame-cell formula: $\alpha + \beta + \gamma + \vartheta = 2 + 2 + 2 + 2$ or 8.

Forked-tailed cercaria with body 0.4 mm. long by 0.19 mm. wide, with tail trunk equally long and with furci about 0.26 mm. long, terminating in very short spinose porcesses. Eye-spots wanting.

Acetabulum 20 μ in diameter, in posterior fourth of body; oral sucker 70 μ in diameter, opening anteriad. Pharynx 30 μ in trans-section; esophagus of narrow bore, opening into thin glandular-walled ceca which run caudad as far as the bladder. Mucin glands wanting.

Sporocyst simple, sausage-shaped sac.

Excretory bladder oval, depressed; collecting tubules four to each side, arising simultaneously from the bladder. Flame cells in four paired groups, the posterior pair being in the tail.

Large mass of germ cells midway between acetabulum and bladder.

Cercaria rhabdocaeca nov. spec. (Fig. 9.)

Systematic position: furcocercous larva.
Parthenita: sporocyst.
Host: *Planorbis trivolvis* Say.
Habitat and time of collection: slough, Urbana, Ill., 1918.
Flame-cell formula: $\alpha + \beta + \gamma + \vartheta + \epsilon = 2 + 2 + 2 + 2 + 2$ or 10.

Forked-tailed cercaria with body 0.14 mm. long by 0.06 mm. wide, with tail trunk practically twice as long, and with furci 0.2 mm. in length. Anterior part of body provided with thick blunt spines. Acetabulum wanting; oral sucker pyriform, with larger end directed inward. Eye-spots wanting.

Sporocyst sacculate, with muscular pocket (not a digestive tract) and birthpore at anterior end.

Prepharynx present; pharynx only slightly muscular; esophagus short and inconspicuous; cecum single median. Mucin glands three to each side of the body, opening through individual ducts at sides of oral aperture. Duct pores capped with hollow piercing spines.

Excretory bladder simple, with collecting tubule emerging

from each side. Flame cells consisting of five paired groups on each side of body.

A few large germ-gland cells located ventral to bladder.

SUMMARY.

1. The number and distribution of groups of flame cells is the fundamental basis of structure of the excretory system of the distomes. Number of flame cells in each group and total number of flame cells are of secondary significance.

2. The group of flame cells is typical of all members of a family or at least of a subfamily.

3. The basic flame-cell group of each family or subfamily may be expressed as a general formula. Substitution in this general formula for the exact number of flame cells in each group shows variations within individual units, which, in each case, are multiples of the common denominator on which the general formula is based.

4. Seven new species of distome cercariæ are described, which are of special importance in affording evidence of the orderliness of the excretory system of the Digenea.

REFERENCES CITED.

Cort, W. W.

'18 Homologies of the Excretory System of Forked-tailed Cercariæ. Jour. Parasit., 4, 49–57, 2 figs.

Faust, E. C.

'17 Notes on the Cercariæ of the Bitter Root Valley, Montana. Jour. Parasit., 3, 105–123, 1 pl.

'18 Life History Studies on Montana Trematodes. Ill. Biol. Monogr., 4, 1–120, 9 pl.

'18a Studies on Illinois Cercariæ. Jour. Parasit., 4, 93–110, 2 pl.

Looss, A.

'94 Die Distomen unserer Fische und Frösche. Bibl. Zoöl., 16, 1–296, 9 Taf.

'96 Recherches sur la faune parasitaire de l'Égypte. Mem. l'institute Égyptien, 3, 1–252, 16 pl.

THE EXCRETORY SYSTEM IN DIGENEA. III.

ERNEST CARROLL FAUST.

NOTES ON THE EXCRETORY SYSTEM IN A MONOSTOME LARVA, *Cercaria spatula* NOV. SPEC.[1]

In two previous papers of this series (Faust, 1919, 1919a) the writer has discussed the excretory system of an amphistome larva, *Cercaria convoluta*, and significant types of this system in distome larvæ. This paper presents data on the development and structure of the excretory system in a monostome larva, *Cercaria spatula* nov. spec. The system will be best presented by first tracing its development.

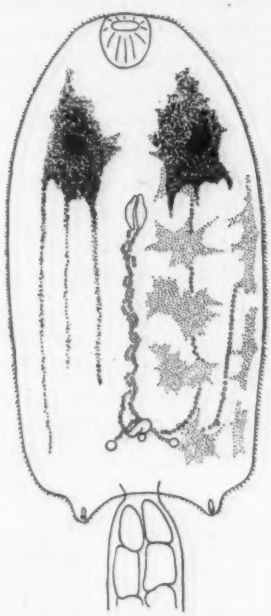
At the time when the cercaria germ-ball begins to differentiate and the tail portion becomes distinguishable from the body, the excretory system is recognizable as a pair of tubules running nearly the length of the animal. Soon the portion in the posterior part of the body proper draws together and fuses to form the bladder. Sometime after this the tail tubules coalesce to form the single median tubule of the mature larva. Meanwhile the tubules anterior to the bladder fuse with one another at their anteriormost ends, thus forming a circuitous tubule from one side to another.

At the earliest stage there is a single flame cell for each side of the body. This is situated at the anterior end of the body. Later this cell wanders backward along the lateral tubule so that at the time when the tubular circuit becomes closed the flame cell occupies a place halfway between the anterior end of the system and the bladder. It then divides into two flame cells, the fundaments of the system. The anterior one wanders forward and by a two-fold bifurcation gives rise to four flame cells. The posterior one wanders backward and by a single bifurcation forms two cells. Thus the flame-cell number of the mature

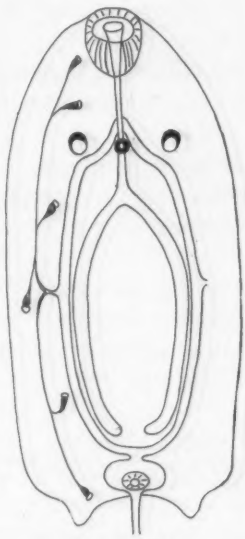
[1] Contributions from the Zoölogical Laboratory of the University of Illinois, No. 132.

cercaria amounts to 12, or 6 on each side of the median line (Fig. 2). Since the two cells on each side of the body, arising from the bifurcation of the original cell, are the key to the further development of the system, the general flame-cell formula may be represented as $\alpha' + \alpha'' = 4 + 2$ or 6.

Data on the excretory system in the redia of *Cercaria spatula* furnish additional evidence in favor of the belief that this formula is valid for the excretory system in this species. In the very



1



2

FIG. 1. *Cercaria spatula*, dorsal view, showing eye-spots, pigmentation, and genital cells. × 170.

FIG. 2. *C. spatula*, dorsal view, showing digestive and excretory systems. × 170.

young redia a single flame cell is found on each side of the body, at the end of a coiled tubule which opens to the outside through an inconspicuous pore. Later a single bifurcation of the flame cell and the distal end of the coiled tubule occurs so that in the mature redia the two collecting tubules on each side open outward

through a single pore (Fig. 3). In the parthenita, then, as well as in the cercaria, the basis of the system is a two-fold one, as expressed in the formula $\alpha' + \alpha''$.

While many monostome cercaria have been described and in most cases the tubular circuit has been figured in the description, the lateral system or secondary tubule has been suggested only once, in *Cercaria robusta* (Faust, 1918). Omission of the more delicate part of the system is undoubtedly due to the ease with which the main mass of the system has been observed, since it is filled with granules, and the extreme difficulty with which

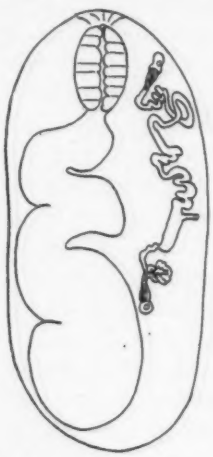


FIG. 3. Very young redia of *C. spatula*, showing digestive tract and flame-cell structure. × 75.

the finer tubules are demonstrated. Since this same type of system is probably common to these two species, the formula $\alpha' + \alpha''$ is quite likely a common denominator for the family or subfamily to which they belong.

Cercaria spatula nov. spec. (Figs. 1–3.)

Systematic position: larval monostome, probably Notocotylidæ.

Parthenita: redia.

Host: *Physa gyrina* Say.

Habitat: Urbana, Illinois, 1918.

Flame-cell formula: $\alpha' + \alpha'' = 4 + 2$ or 6.

Monostome larva of spatulate outline, with a length of about 0.5 mm. and a width of nearly half that measurement; tail equally long and capable of great distension along its transverse axis and great extension along its longitudinal axis. Body entirely covered with minute spines. Trioculate, with dense masses of melanoidin pigment around the lateral eyes, extending caudad along the six posterior nerve trunks; integument of entire body more or less infiltrated with pigment granules. Locomotor pockets at posterior part of body, small, simple. Tail aspinose with six continuous pairs of large vacuolated cells at sides of caudal excretory canal.

Oral sucker leading into a long narrow esophagus; esophagus branching some little distance behind the median eye to form a typical furculum.

Excretory bladder ovate, transversely compressed, with a strong sphincter; main circuitous collecting tubule with a main branch on each side; flame cells anterior to main branch four posterior to main branch two.

Genital organs consisting of median ovary, paired testes in plane slightly behind ovary, uterus and vas deferens leading forward respectively to vagina and cirrus sac; vitellaria of two series of five inner and three outer glands on dorsal side of body.

Redia with long rhabdocœl gut, strong pharynx lined with transverse chitinous ribbing, and spines anterior and posterior to pharynx. Birthpore inconspicuous. Flame cells two for each side of the body.

Cystogenous granules many, densely opaque. Decaudation slow; encystment very slow.

Summary.

1. Development of the excretory system in the monostome larva *Cercaria spatula* nov. spec. gives support to the principle of orderly development and conservatism of the system in monotome larvæ.

2. Comparison of the system in the cercaria and redia of this species yields evidence that there is a fundamental homology of the units in the hermaphroditic and the parthenogenetic generations of this fluke.

REFERENCES CITED.

Faust, E. C.

'18 Studies on Illinois Cercariæ. Jour. Parasit., 4, 93–110, 2 pl.

'19 The Excretory System in Digenea. I. Notes on the Excretory System of an Amphistome, *Cercaria convoluta* nov. spec. BIOL. BULL., 36, 315–321.

'19a The Excretory System in Digenea. II. Observations on the Excretory System in Distome Cercariæ. BIOL. BULL., 36, 322–339.

THE MARINE BIOLOGICAL LABORATORY

Twenty-First Report; for the Year 1918

Thirty-First Year

I. Trustees (as of August, 1918) 345
II. Act of Incorporation 346
III. By-Laws of the Corporation 347
IV. The Treasurer's Report 349
V. The Librarian's Report 352
VI. The Director's Report 352
Statement 352
1. The Staff 356
2. Investigators and Students 358
3. Tabular View of Attendance 362
4. Subscribing Institutions 363
5. Evening Lectures 364
6. Members of the Corporation 364

I. TRUSTEES

EX OFFICIO

Frank R. Lillie, *Director*, The University of Chicago.
Gilman A. Drew, *Assistant Director*, Marine Biological Laboratory.
D. Blakely Hoar, *Treasurer*, 161 Devonshire Street, Boston, Mass.
Gary N. Calkins, *Clerk of the Corporation*, Columbia University.

TO SERVE UNTIL 1922

Cornelia M. Clapp, Mount Holyoke College.
E. G. Conklin, Princeton University.
Ross G. Harrison, Yale University.
Camillus G. Kidder, 27 William Street, New York City.
M. M. Metcalf, Oberlin, Ohio.
William Patten, Dartmouth College.
Jacob Reighard, University of Michigan.
W. B. Scott, Princeton University.

TO SERVE UNTIL 1921

S. F. Clarke, Williamstown, Mass.
Charles A. Coolidge, Ames Building, Boston, Mass.

C. R. CRANE, Woods Hole, Mass., *President of the Corporation.*
ALFRED G. MAYOR, Carnegie Institution.
C. E. MCCLUNG, University of Pennsylvania.
T. H. MORGAN, Columbia University.
ERWIN F. SMITH, United States Department of Agriculture.
E. B. WILSON, Columbia University.

TO SERVE UNTIL 1920

H. H. DONALDSON, Wistar Institute of Anatomy and Biology.
M. J. GREENMAN, Wistar Institute of Anatomy and Biology.
C. W. HARGITT, Syracuse University.
H. S. JENNINGS, Johns Hopkins University.
GEORGE LEFEVRE, University of Missouri, *Secretary of the Board.*
A. P. MATHEWS, The University of Chicago.
G. H. PARKER, Harvard University.
HENRY B. WARD, University of Illinois.

TO SERVE UNTIL 1919

H. C. BUMPUS, Tufts College.
R. A. HARPER, Columbia University.
W. A. LOCY, Northwestern University.
JACQUES LOEB, The Rockefeller Institute for Medical Research.
GEORGE T. MOORE, Missouri Botanical Garden, St. Louis.
L. L. NUNN, Telluride, Colo.
W. J. V. OSTERHOUT, Harvard University.
JOHN C. PHILLIPS, 299 Berkeley Street, Boston, Mass.

II. ACT OF INCORPORATION

No. 3170.

COMMONWEALTH OF MASSACHUSETTS

Be It Known, That whereas Alpheus Hyatt, William Sanford Stevens, William T. Sedgwick, Edward G. Gardiner, Susan Minns, Charles Sedgwick Minot, Samuel Wells, William G. Farlow, Anna D. Phillips and B. H. Van Vleck have associated themselves with the intention of forming a Corporation under the name of the Marine Biological Laboratory, for the purpose of establishing and maintaining a laboratory or station for scientific study and investigation, and a school for instruction in biology and natural history, and have complied with the provisions of the statutes of this Commonwealth in such case made and provided, as appears from the certificate of the

President, Treasurer, and Trustees of said Corporation, duly approved by the Commissioner of Corporations, and recorded in this office;

Now, therefore, I, HENRY B. PIERCE, Secretary of the Commonwealth of Massachusetts, *do hereby certify* that said A. Hyatt, W. S. Stevens, W. T. Sedgwick, E. G. Gardiner, S. Minns, C. S. Minot, S. Wells, W. G. Farlow, A. D. Phillips, and B. H. Van Vleck, their associates and successors, are legally organized and established as, and are hereby made, an existing Corporation, under the name of the MARINE BIOLOGICAL LABORATORY, with the powers, rights, and privileges, and subject to the limitations, duties, and restrictions, which by law appertain thereto.

Witness my official signature hereunto subscribed, and the seal of the Commonwealth of Massachusetts hereunto affixed, this twentieth day of March, in the year of our LORD ONE THOUSAND, EIGHT HUNDRED and EIGHTY-EIGHT. HENRY B. PIERCE,

[SEAL.] *Secretary of the Commonwealth.*

III. BY-LAWS OF THE CORPORATION OF THE MARINE BIOLOGICAL LABORATORY

I. The annual meeting of the members shall be held on the second Tuesday in August, at the Laboratory, in Woods Hole, Mass., at 12 o'clock noon, in each year, and at such meeting the members shall choose by ballot a Treasurer and a Clerk, who shall be, *ex officio*, members of the Board of Trustees, and Trustees as hereinafter provided. At the annual meeting to be held in 1897, not more than twenty-four Trustees shall be chosen, who shall be divided into four classes, to serve one, two, three, and four years, respectively, and thereafter not more than eight Trustees shall be chosen annually for the term of four years. These officers shall hold their respective offices until others are chosen and qualified in their stead. The Director and Assistant Director, who shall be chosen by the Trustees, shall also be Trustees, *ex officio*.

II. Special meetings of the members may be called by the Trustees, to be held in Boston or in Woods Hole at such time and place as may be designated.

III. The Clerk shall give notice of meetings of the members by publication in some daily newspaper published in Boston at least fifteen days before such meeting, and in case of a special meeting the notice shall state the purpose for which it is called.

IV. Twenty-five members shall constitute a quorum at any meeting.

V. The Trustees shall have the control and management of the affairs of the Corporation; they shall present a report of its condition at every annual meeting; they shall elect one of their number President and may choose such other officers and agents as they may think best; they may fix the compensation and define the duties of all the officers and agents; and may remove them, or any of them, except those chosen by the members, at any time; they may fill vacancies occurring in any manner in their own number or in any of the offices. They shall from time to time elect members to the Corporation upon such terms and conditions as they may think best.

VI. Meetings of the Trustees shall be called by the President, or by any two Trustees, and the Secretary shall give notice thereof by written or printed notice sent to each Trustee by mail, postpaid. Seven Trustees shall constitute a quorum for the transaction of business. The Board of Trustees shall have power to choose an Executive Committee from their own number, and to delegate to such Committee such of their own powers as they may deem expedient.

VII. The President shall annually appoint two Trustees, who shall constitute a committee on finance, to examine from time to time the books and accounts of the Treasurer, and to audit his accounts at the close of the year. No investments of the funds of the Corporation shall be made by the Treasurer except approved by the finance committee in writing.

VIII. The consent of every Trustee shall be necessary to dissolution of the Marine Biological Laboratory. In case of dissolution, the property shall be given to the Boston Society of Natural History, or some similar public institution, on such terms as may then be agreed upon.

IX. These By-Laws may be altered at any meeting of the Trustees, provided that the notice of such meeting shall state that an alternation of the By-Laws will be acted upon.

X. Any member in good standing may vote at any meeting, either in person or by proxy duly executed.

IV. THE TREASURER'S REPORT

MARINE BIOLOGICAL LABORATORY BALANCE SHEET, DECEMBER 31, 1918.

Assets.

Cash in bank	$ 7,503.52	
Petty cash at Woods Hole	200.00	$ 7,703.52
Notes receivable		1,000.00
Accounts receivable		10,938.88
Inventories (not available)		
Items in suspense		11.73
Investments (Schedule I.)	$ 11,768.83	
Investment cash (Schedule II.)	485.20	12,254.03
Gansett property account	$ 22,317.20	
Less mortgage	14,629.21	7,687.99
Educational plant (Schedule III.):		
Land	$95,856.14	
Buildings	169,670.49	
Equipment	75,920.25	
	$341,446.88	
Less reserve for depreciation	21,140.24	320,306.64
		$359,902.79

Liabilities.

Bills payable		$ 90.58
Notes payable	$ 2,300.00	
Trust funds	9,954.03	12,254.03
		$ 12,344.61
Balancing account:		
Balance, January 1	$254,157.31	
Special donations	1,261.59	
Sundry adjustments	6.79	
	$355,425.69	
Less: Adjustment of depreciation reserve, 1917	$ 5,209.01	
Excess of expenses for year	2,658.50	
	$ 7,867.51	$347,558.18
		$359,902.79

MARINE BIOLOGICAL LABORATORY INCOME AND EXPENSES FOR YEAR ENDED DECEMBER 31, 1918

	Expense	Income	Loss	Gain
Administrative expense	$ 7,592.98		$ 7,592.98	
Bar Neck property expense	80.00		80.00	

Biological Bulletin and annual dues	$ 2,341.57	$ 2,387.94		$ 46.37
Boat department	6,378.42		6,378.42	
Carpenter department	868.35	21.52	846.83	
Chemical department	1,436.27		1,436.27	
Club House expense	196.91		196.91	
Dexter House special expense	437.61		437.61	
Dormitory department	1,589.98	1,528.76	61.22	
Fish trap	1,323.62	1,360.10		36.48
Instruction	3,133.22	3,475.00		341.78
Interest on notes payable	150.00		150.00	
Lectures, evening	122.14		122.14	
Library department	1,492.70		1,492.70	
Maintenance, buildings and grounds	3,056.50		3,056.50	
Mess	19,672.60	21,016.28		1,343.68
New laboratory expense	3,245.28		3,245.28	
Newman cottage	49.19	175.00		125.81
Pumping station expense	378.07		378.07	
Research department		3050.00		3,050.00
Sundry expense and income	1,807.57	2,519.41		711.84
Supply department	13,304.60	18,748.04		5,443.44
Truck	1,029.56		1,029.56	
Total current expenses	$69,687.14	$54,282.05	$26,504.49	$11,099.40
Total income	54,282.05		11,099.40	
Excess of expenses	$15,405.09		$15,405.09	
Depreciation	7,189.41			
Bad accounts charged off	64.00			
	$22,658.50			
Contribution by Friendship Fund, Incorporated	20,000.00			
Balance to balancing account	$ 2,658.50			

Marine Biological Laboratory Investments (Book Values), December 31, 1918.

Reserve Fund

$3,000 American Telephone & Telegraph Company, 4's (represented by receipts for same as collateral)	$2,921.25	
$500 Western Telephone & Telegraph Company 5's	496.88	
6 shares American Smelting & Refining Company, Preferred (receipt on file)	732.00	
8 shares General Electric Company	948.05	
14 shares United Shoe Machinery Company, Preferred	393.75	
5 shares Massachusetts Gas Companies, Preferred	444.63	$5,936.56

Lucretia Crocker Fund

$300 Liberty Loan Bonds, 4¼'s	$ 300.00	
½ of $1,000.00 American Telephone & Telegraph Company's 4's	194.75	

18 shares Vermont and Massachusetts Railroad Company	$2,416.50	
1 share American Telephone & Telegraph Company	125.02	
3 shares General Electric Company	364.85	
1 share West End Street Railway Company	83.00	3,484.12

Library Fund

$300 Liberty Loan Bonds, 4¼'s	$ 300.00	
⅘ of $1,000 American Telephone & Telegraph Company, 4's	779.00	
3 shares American Telephone & Telegraph Company	375.04	
1 share American Smelting & Refining Company Preferred (receipt on file)	122.00	
3 shares General Electric Company	362.10	
5 shares United Shoe Machinery Company, Preferred	140.63	
3 shares Massachusetts Gas Companies, Preferred	269.38	$2,348.15
Total, Exhibit A		$11,768.83

HARVEY S. CHASE & COMPANY CERTIFIED PUBLIC ACCOUNTANTS,
84 STATE ST., BOSTON

MR. D. BLAKELEY HOAR, February 11, 1919
161 Devonshire Street,
Boston.

Dear Sir: We have completed our audit of the accounts of the Marine Biological Laboratory for the year ended December 31, 1918, as kept both at your office in Boston and at Woods Hole, and report thereon in the accompanying exhibits and schedules:

Exhibit A—Balance-Sheet as of December 31, 1918.
B—Income-and-Expense for the year ended December 31, 1918.

Schedule I—Investments (Book Values).
II—Cash Receipts and Payments on account of Investments.
III—Summary of Inventory of Land, Buildings and Equipment.
IV—Depreciation Reserve.

We certify that, subject to the comments herewith, the balance-sheet and income-and-expense statement shown in Exhibits A and B are in accordance with the books and correct to the best of our knowledge and belief.

Very respectfully,
HARVEY S. CHASE & COMPANY,
Certified Public Accountants.

V. STATEMENT CONCERNING THE LIBRARY

On account of the exceptional conditions of the state of war, it was found impossible to carry out any external enterprise, and in the absence of the assistant librarian, other work was limited. For these reasons the main effort was devoted to extension of the catalogues. In addition, a number of gifts were accessioned. Among these must be mentioned the gift by Miss Katharine Foot of about 750 reprints from her collection, expecially rich in cytology, and the gift by Dr. Ida H. Hyde of a most valuable collection of about 1,900 books and reprints on physiological subjects. These gifts are particularly valuable as they constitute research collections including many rare publications at least two thirds of which are new to the Library. The coöperation of investigators has been a most important factor in building up the library.

VI. THE DIRECTOR'S REPORT

January 1, 1919

To the Trustees of the Marine Biological Laboratory:

Gentlemen: I beg to present herewith a report of the thirty-first session of the Marine Biological Laboratory for the year 1918. Our anticipation both last season and this, that the war would affect our regular work unfavorably has been to a certain extent realized. But the conclusion of the war nevertheless finds us in a strong position, with our organization intact, and no actual suspension of our work incurred in spite of a considerable diminution of it.

If we examine the tabular view of attendance given under 3 beyond, we find that the total attendance for the last four years was: 1915, 242; 1916, 231; 1917, 212; 1918, 161. The attendance of investigators during the same period was cut down from 137 to 92, and of students from 105 to 69. The greatest proportional loss was among the younger investigators, whose numbers were reduced to less than one half. This is explained by the fact that the young men were serving our country in

various technical capacities. There was a corresponding reduction in receipts from students and investigators: 1915, $8,325; 1916, $8,725; 1917, $7,850; 1918, $6,530. The receipts of the Supply Department were $18,748.04 as against $18,815.22 in 1917; $21,096.65 in 1916; and $16,932.00 in 1915.

It was possible to effect various economies corresponding to the somewhat smaller scale of operations, and the treasurer's report shows a net excess of receipts over expenditures for the year amounting to $4,594.91. Out of total expenditures of $69,687.14, Mr. Crane furnished $20,000.00 through the Friendship Fund, Inc., for which our best thanks seem singularly inadequate. The name of the Fund expresses the spirit of the giver, and the spirit of the Laboratory toward Mr. and Mrs. Crane in ever increasing degree if that is possible.

As stated in the last annual report,[1] shortly after beginning of the war the Laboratory leased to the United States of America for the Navy Department without compensation, the Mess-hall, laundry, kitchen and storehouse, the Homestead and the lecture hall building from September 15, 1917, to May 15, 1918. On the conclusion of this period the lease was renewed, with certain adjustments to cover the summer session, until June 30, 1919. The Navy Department so coöperated with us that we were able to continue our work without interruption. During the summer of 1918, the members of the Naval Reserve at Woods Hole were furnished board at the Mess which was run by the Laboratory as usual, and at the close of the summer session the Navy Department took it over again. The plan worked harmoniously, and I feel we owe an acknowledgment to the Navy personnel for the courtesy with which all elements of the situation were invariably met. Of the 200 members of the Naval Reserve at Woods Hole, one half was furnished board at the Mess while the other half was on duty with the boats, and these sections alternated. Owing to conclusion of the armistice, the lease will be terminated from and after January 31, 1919.

The Laboratory is glad to have made the above small contribution to the winning of the war. Many of the members of the staff, the Board of Trustees, and of the Corporation have been

[1] BIOLOGICAL BULLETIN, Vol. 35, p. 142.

concerned in war work, some by enlistment in various branches of the armed forces of the United States, others by service on various scientific boards, others again by undertaking specific pieces of investigation for the Government. As a consequence there were many absences from the staff and investigators in the summer. Those who were able to do so took up the work of the absent members, and recognition is due for the efficiency with which they conducted the work of the Laboratory.

The Tablet in memory of the First Director of the Laboratory was designed by Miss Frances Grimes of New York City, and was completed and set up in the vestibule of the brick building in the spring of 1918. It is of bronze, and bears the following inscription: "To the Memory of Charles Otis Whitman, 1842–1910, Professor of Zoölogy in Universities of Japan and the United States, 1877–1910. First Director of the Marine Biological Laboratory, 1888–1908. This tablet is erected by the Corporation and Board of Trustees of the Marine Biological Laboratory in grateful recognition of his inspiring Leadership, Devotion to the Spirit of Coöperation among Scientific Men, high ideals of Research, and of his great work in the Advancement of Biological Science."

May this memorial serve to keep green the memory of the man who more than any other, established the spirit of the Marine Biological Laboratory:

The death of Franklin P. Mall, Professor of Anatomy in Johns Hopkins Medical School occasioned a serious loss to the Laboratory. The following resolution has been entered in the minutes of the Board of Trustees:

"Franklin Paine Mall died at Baltimore, November 17, 1917, in his fifty-sixth year and just as he was entering on the most comprehensive phase of his work in human embryology.

"Since 1897 he had been a member of the Board of Trustees of the Marine Biological Laboratory.

"The aims and ideals of the Laboratory were close to his heart, and many young investigators who have studied at Woods Hole owe to his suggestion their impulse to do this.

"A student of broad biological training and still broader interests; a teacher of genius; a skilful organizer of scientific

work and workers; an investigator with a peculiar gift for the appreciation of form and with a strong artistic sense; a whimsical counsellor, blending wise sayings with his common talk. . . . This Board owes much to him, and on this occasion desires to record its sorrow for his too early death and its appreciation of his qualities."

The vacancy in the Board of Trustees caused by the death of Professor Mall has been filled by the election of W. J. V. Osterhaut, Professor of Botany in Harvard University.

We record with sorrow the death from pheumonia on January 29, 1919, of Professor William E. Kellicott, head of the Department of Biology of the College of the City of New York and of the Department of Embryology of the Marine Biological Laboratory. During his long connection with our Laboratory, as investigator in 1903, instructor in embryology 1908–1914, and head of this department since 1915, Professor Kellicott won many friends and rendered most valuable service. His loss will be deeply felt by his friends and by the Laboratory.

War conditions prevented any considerable development of the Gansett property in 1918. The plans stated in the last report were however carried through. The Town of Falmouth accepted the main road (Whitman Road) and part of Gansett Road, which are now town roads, and purchased the water system installed by the Laboratory on these roads at cost. Two residences have been erected. The Laboratory has paid off $1,781.60 on the mortgage, and holds to the credit of the Gansett account $2,522.66 in cash, and a mortgage of $1000.00 on two of the lots with residence.

The Laboratory has come through a period of serious uncertainty without harm. Now that this period of suspense is over, we are confronted with an opportunity for usefulness greater by all that has been lost by Europe in the matter of scientific usefulness, and by the spirit of heightened scientific activity that has been aroused in America during the stirring times of war. It is perhaps not so much an opportunity as a duty to see that American institutions of learning compensate the world to some extent for what has been lost. In our field of work this duty and this opportunity are ours.

I. THE STAFF

1918

THE STAFF

FRANK R. LILLIE, *Director*, Professor of Embryology, and Chairman of the Department of Zoölogy, The University of Chicago.

GILMAN A. DREW, *Assistant Director*, Marine Biological Laboratory.

ZOÖLOGY

I. INVESTIGATION

GARY N. CALKINS, Professor of Protozoölogy, Columbia University.

E. G. CONKLIN, Professor of Zoölogy, Princeton University.

GILMAN A. DREW, Assistant Director, Marine Biological Laboratory.

GEORGE LEFEVRE, Professor of Zoölogy, The University of Missouri.

FRANK R. LILLIE, Professor of Embryology, The University of Chicago.

C. E. MCCLUNG, Professor of Zoölogy, University of Pennsylvania.

T. H. MORGAN, Professor of Experimental Zoölogy, Columbia University.

E. B. WILSON, Professor of Zoölogy, Columbia University.

II. INSTRUCTION

CASWELL GRAVE, Associate Professor of Zoölogy, Johns Hopkins University. (Absent in 1918.)

W. C. ALLEE, Professor of Biology, Lake Forest College. In charge in 1918.

GEORGE A. BAITSELL, Instructor in Biology, Yale University. (Absent in 1918.)

ROBERT CHAMBERS, JR., Cornell University Medical College.

G. S. DODDS, Assistant Professor of Zoölogy, University of Missouri.

W. J. KOSTIR, Instructor in Zoölogy and Entomology, Ohio State University.

ANN H. MORGAN, Professor of Zoölogy, Mount Holyoke College.

CHARLES L. PARMENTER, Research Fellow, University of Pennsylvania.

EMBRYOLOGY

I. INVESTIGATION

(*See Zoölogy*)

II. INSTRUCTION

WILLIAM E. KELLICOTT, Professor of Biology, Goucher College (absent in 1918.)

ROBERT A. BUDINGTON, Professor of Zoölogy, Oberlin College, (In charge in 1918.)

CHARLES G. ROGERS, Professor of Comparative Physiology, Oberlin College.

HUBERT B. GOODRICH, Associate Professor of Zoölogy, Wesleyan University.

PHYSIOLOGY

I. INVESTIGATION

ALBERT P. MATHEWS, Professor of Physiological Chemistry, The University of Chicago. (Absent in 1918.)

RALPH S. LILLIE, Professor of Biology, Clark University.

HAROLD C. BRADLEY, Assistant Professor of Physiological Chemistry. University of Wisconsin.

II. INSTRUCTION

RALPH S. LILLIE, Professor of Biology, Clark University.

WALTER E. GARREY, Professor of Physiology, Tulane University. (Absent in 1918.)

FRANK P. KNOWLTON, Professor of Physiology, Syracuse University.

A. R. MOORE, Professor of Physiology, Rutgers College.

PHILOSOPHICAL ASPECTS OF BIOLOGY AND ALLIED SCIENCES

LECTURES

EDWARD G. SPAULDING, Professor of Philosophy, Princeton University. (Absent in 1918.)

BOTANY

GEORGE T. MOORE, Director, Missouri Botanical Garden and Professor of Botany, Washington University.

IVEY F. LEWIS, Professor of Biology, University of Virginia.

WILLIAM D. HOYT, Associate Professor of Biology, Washington and Lee University.

LIBRARY

H. McE. KNOWER, Professor of Anatomy, University of Cincinnati. Librarian.

MARY E. SCOTT, Assistant Librarian.

CHEMICAL SUPPLIES[1]

OLIVER S. STRONG, Assistant Professor of Neurology, College of Physicians and Surgeons, New York City, Chemist.

[1] Compound microscopes, with two oculars and two objectives, rack and pinion and fine adjustment, may be rented for the season at $7.00 each provided notice is received by the assistant director not later than June 15.

SUPPLY DEPARTMENT

G. M. GRAY, Curator.
JOHN J. VEEDER, Captain.
E. M. LEWIS, Engineer.
A. W. LEATHERS, Collector.
A. M. HILTON, Collector.
J. MCINNIS, Collector.
F. G. GUSTAFSON, Collector in Botany.
EDNA E. WELLS, Clerk.

F. M. MACNAUGHT, Business Manager.
HERBERT A. HILTON, Superintendent of Buildings and Grounds.

2. INVESTIGATORS AND STUDENTS

1918

ZOÖLOGY

Independent Investigators

ADDISON, WILLIAM H. F., Assistant Professor of Normal Histology and Embryology, University of Pennsylvania.
ALLEE, WARDER C., Professor of Biology, Lake Forest College.
ALLEN, EZRA, Research Fellow, University of Pennsylvania.
ALTENBURG, EDGAR, Instructor in Biology, Rice Institute.
ANDO, HIDEZO, University of Kyoto, Japan.
BECKWITH, CORA J., Associate Professor of Zoölogy, Vassar College.
BIGNEY, Andrew J., Assistant in Zoölogy, Harvard University.
BORING, ALICE M., Associate Professor of Zoölogy, University of Maine.
BRIDGES, CALVIN B., Research Assistant, Columbia University.
BUDINGTON, ROBERT A., Professor of Zoölogy, Oberlin College.
CALKINS, GARY N., Professor of Protozoölogy, Columbia University.
CAROTHERS, E. ELEANOR, Assistant in Zoölogy, University of Pennsylvania.
CLAPP, Cornelia M., Emeritus Professor of Zoölogy, Mount Holyoke College.
CLARK, ELIOT R., Professor of Anatomy, University of Missouri.
CLARK, ELEANOR L., Columbia, Mo.
COPELAND, MANTON, Professor of Biology, Bowdoin College.
COWDRY, Edmund V., Professor of Anatomy, Peking Union Medical College.
CRAMPTON, H. E., Professor of Zoölogy, Barnard College.
DEXTER, JOHN S., Assistant Professor of Zoölogy, University of Saskatchewan.
DODDS, GIDEON S., Assistant Professor of Zoölogy, University of Missouri.
DONALDSON, HENRY H., Professor of Neurology, Wistar Institute.
DREW, GILMAN A., Assistant Director, Marine Biological Laboratory, Woods Hole.
GLASER, OTTO C., Professor of Biology, Amherst, Mass.
GOODRICH, HUBERT B., Associate Professor of Zoölogy, Wesleyan University.
GOULD, HARLEY N., Assistant Professor, West Virginia University Medical School.
GREGORY, Louise H., Assistant Professor of Zoölogy, Barnard College.
KINDRED, JAMES E., Graduate Fellow, University of Illinois.
KNOWER, HENRY MCE., Professor of Anatomy, University of Cincinnati.
LILLIE, Frank R., Chairman Department of Zoölogy, University of Chicago.

McCLUNG, CLARENCE E., Director of Zoölogical Laboratory, University of Pennsylvania.
MOHR, OTTO L., Prosector, University of Kristiania.
MINER, Roy W., Associate Curator of Invertebrate Zoölogy, American Museum of Natural History.
MORGAN, ANN H., Professor of Zoölogy, Mount Holyoke College.
MORGAN, THOMAS H., Professor of Experimental Zoölogy, Columbia University.
MORRILL, Charles V., Instructor in Anatomy, Cornell Medical College.
MULLER, Hermann J., Instructor, Rice Institute.
NABOURS, Robert K., Professor of Zoölogy, Kansas Agricultural College.
PACKARD, CHARLES, Instructor in Zoölogy, Columbia University.
PARKER, GEORGE H., Professor of Zoölogy, Harvard University.
PARMENTER, Charles L., Research Fellow, University of Pennsylvania.
PATTEN, WILLIAM, Professor of Biology, Dartmouth College.
PATTEN, BRADLEY M., Assistant Professor of Histology and Embryology, Western Reserve University.
PLOUGH, HAROLD H., Instructor in Biology, Amherst College.
ROGERS, CHARLES G., Professor of Comparative Physiology, Oberlin College.
STOCKARD, CHARLES R., Professor of Anatomy, Cornell University Medical College.
STRONG, OLIVER S., Assistant Professor of Neurology, Columbia University.
STURTEVANT, ALFRED H., Research Assistant, Columbia University.
WARREN, HOWARD C., Stuart Professor of Psychology, Princeton University.
WHITING, PHINEAS W., Harrison Research in Zoölogy, University of Pennsylvania.
WILSON, EDMUND B., Professor of Zoölogy, Columbia University.
WOODWARD, ALVALYN E., Instructor, Simmons College.

Beginning Investigators

ADAMS, A. ELIZABETH, Instructor in Zoölogy, Mount Holyoke College.
CARLSON, C. O., Professor of Biology, Doane College.
COLLETT, MARY E., Fellow in Zoölogy, University of Pennsylvania.
DAVIES, I. J., Technician, Rice Institute.
DONOVAN, STEPHEN M., Professor of Biology, St. Bonaventure's College.
GOODRICH, CLARA C., Middletown, Conn.
HEDGE, MABEL L., Technician, Columbia University.
HOWLAND, Ruth B., Associate Professor of Biology, Sweet Briar College.
KOSTIR, W. J., Instructor in Zoölogy, Ohio State University.
MATSUI, KENKICHI, Agricultural College of Morioka, Japan.
NONIDEZ, JOSE, F., Professor of Zoölogy, University of Murcia, Spain.
OLSEN, CHRIS E., Preparator, American Museum of Natural History.
SCHRADER, FRANZ, Assistant, Columbia University.
SHIMOTORI, SHOW, Artist, American Museum of Natural History.
STARR, ISAAC, JR., University of Pennsylvania.
WALLACE, EDITH M., Research Assistant, Columbia University.

PHYSIOLOGY

Independent Investigators

CHAMBERS, ROBERT JR., Instructor in Anatomy, Cornell University Medical College.
CLOWES, GEORGE H. A., Biological Chemist, New York State Institute for Study of Malignant Diseases.

DERNBY, KARL G., Rockefeller Institute.
EDWARDS, DAYTON J., Lecturer in Physiology, Cornell University Medical College.
HARVEY, E. NEWTON, Assistant Professor of Physiology, Princeton University.
HARVEY, MRS. E. NEWTON, Princeton, N. J.
HECHT, SELIG, Assistant Professor of Physiology, Creighton University Medical School.
HYDE, IDA H., Professor of Physiology, University of Kansas.
JUST, ERNEST E., Professor of Physiology, Howard University.
KNOWLTON, FRANK P., Professor of Physiology, Syracuse University.
LILLIE, RALPH S., Professor of Biology, Clark University.
LOEB, JACQUES, Head of Department of Experimental Biology, Rockefeller Institute for Medical Research.
MOORE, ARTHUR R., Professor of Physiology, Rutgers College.
MOORE, MRS. ARTHUR R., New Brunswick, N. J.
REDFIELD, ALFRED C., Instructor in Physiology, Harvard Medical School.
SPAETH, REYNOLD, A., Associate in Physiological Hygiene, Baltimore, Md.

Beginning Investigators

BANUS, MARIO G., Rockefeller Institute.
BRIGHT, ELIZABETH M., Technician, Harvard Medical School.
IRWIN, MARIAN, Graduate Student, Radcliffe College.

BOTANY

Independent Investigators

EAST, EDWARD M., Professor Experimental Plant Morphology, Harvard University.
HOYT, WILLIAM D., Associate Professor of Biology, Washington and Lee University.
LEWIS, IVEY F., Professor of Biology, University of Virginia.
MOORE, GEORGE T., Director, Missouri Botanical Garden.
OSTERHOUT, WINTHROP J. V., Professor of Botany, Harvard University.

Beginning Investigators

BROOKS, MRS. S. C., 333 Longwood Ave., Boston, Mass.
THOMAS, HELEN S., Radcliffe College.

STUDENTS

1918

ZOÖLOGY

ABRAMS, EDITH H., Assistant in General Zoölogy, Mount Holyoke College.
BALDWIN, EVA E., Goucher College.
BROWN, MARY, Student, Butler College.
CLARK, ROSAMOND, 40 Commonwealth Ave., Boston, Mass.
CLARKE, ALICE E., Student, Goucher College.
CLOSSON, MARY B., Student, Ursinus College.
COLCORD, Edward C., Student, Oberlin College.
DABOLL, MARY, Student, Mount Holyoke College.

EBELING, KARL W., Student, Johns Hopkins University.
ELLIOTT, Grace E., Knox College.
FLAIG, Julian V., Student, Princeton University.
GATES, GORDON E., Student, Colby College.
GREENE, Charlotte L., Student, Barnard College.
HANSON, FRANK B., Instructor, Washington University.
HYDE, ALICE, Student, Mount Holyoke College.
JONES, HAROLD E., Assistant, Amherst College.
KOERNER, SOPHIE, Student, Barnard College.
KRAFKA, Elizabeth B., Laboratory Assistant, Lake Forest College.
KRANZ, ALETHA, Student, University of Chicago.
LAGEMANN, ANNA E., Student, Barnard College.
LILLIE, CATHERINE C., Student, Vassar College.
LUPO, PATSY, Mount Holyoke College.
MCCASH, GLADYS K., Student, Mount Holyoke College.
MCCLAY, EDITH L., Student, Mount Holyoke College.
MASON, ELEANOR D., Student, Mount Holyoke College.
MEADE, RICHARD H., JR., University of Virginia.
METCALF, RACHEL V., Oberlin College.
MULHERON, HELEN, Teacher of English, St. Michaels School.
MULLINS, MARY R., Hunter College.
OAK, DOROTHY, Student, Barnard College.
POLK, REBEKA, Student, Mount Holyoke College.
POWIS, ETHEL M., Student, Mount Holyoke College.
PRICE, GENEVIEVE, Student, Oberlin College.
SEAVER, CHARLOTTE, Sweet Briar College.
SHONKA, EMIL F., Student, St. Procopius College.
STEWART, WALTER B., Student, Princeton University.
THOMPSON, MARTHA L., Student, Knox College.
TROTTER, MILDRED, Student, Mount Holyoke College.
WHEATLEY, MARJORIE A., Student, Vassar College.
WHITE, FRANCES W., Student, Oberlin College.
WILLMANN, EDITH, Student, Barnard College.

EMBRYOLOGY

ABT, ARTHUR F., Student, University of Chicago.
AGERSBORG, H. P. K., Tutor, College of City of New York.
BROWN, ALICE L., Assistant Instructor, University of Kansas.
CAULDWELL, KATHARINE, Student, Bryn Mawr College.
HOSFORD, CAROLINE A., Instructor in Zoölogy, Doane College.
HUGHES, SALLY P., Instructor, Grinnell College.
HUGHES, J. ARTHUR, Student, Carleton College.
MILLER, ERWIN C., Student, Dartmouth College.
NORRIS, HENRY M., Student, Princeton University.
SEAGO, MARY M., Student, Sophie Newcomb College.
STEDMAN, HAZELTENE L., Student, Mount Holyoke College.
WOLFF, DOROTHY, Assistant in Comparative Anatomy in Mount Holyoke College.

PHYSIOLOGY

BASKERVILL, MARGARET L., Instructor in Biology, Mississippi Industrial Institute and College.
BROKAW, EUNICE, Student, Knox College.
FULTON, B. B., Assistant Entomologist, New York Agricultural Experiment Station.
GREEN, SUSAN A., Professor of Biology, Maryville College.
HINRICHS, MARIE A., Student, University of Chicago.
HOLLAND, DOROTHY F., Mount Holyoke College.
MARTIN, BERTHA E., Assistant Professor of Biology, Wheaton College.
MONTGOMERY, PRISCILLA B., University of Pennsylvania.
SPENCER, HELEN W., Student, Radcliffe College.
STREESEMAN, ADELE E., Instructor in Physics, Vassar College.

BOTANY

BEYER, HENRY G., U. S. Navy, Retired.
CHADBOURNE, JOSEPH H., JR., 11 Irvington St., Waban, Mass.
FESSENDEN, ANNA P., Smith College.
FOUTS, JANET W., Barnard College.
JEWETT, GLADYS E., Student, Wheaton College.
TUTTLE, GURYNETHE, M., Instructor in Botany, University of Alberta.

3. TABULAR VIEW OF ATTENDANCE

	1914	1915	1916	1917	1918
INVESTIGATORS—Total	129	137	129	129	93
Independent:					
Zoölogy	62	69	70	63	51
Physiology	22	20	23	23	16
Botany	10	6	7	8	5
Under Instruction:					
Zoölogy	31	36	25	24	16
Physiology	1	4	3	6	3
Botany	3	2	1	5	2
STUDENTS—Total	89	105	102	83	69
Zoölogy	43	47	50	46	41
Embryology	21	37	26	16	12
Physiology	10	15	14	13	10
Botany	15	6	12	8	6
TOTAL ATTENDANCE	218	242	231	212	162
INSTITUTIONS REPRESENTED—Total	77	79	73	77	72
By investigators	51	59	51	60	49
By students	47	42	45	36	38
SCHOOLS AND ACADEMIES REPRESENTED.					
By investigators	1	3	–	2	–
By students	5	9	3	5	–

4. SUBSCRIBING INSTITUTIONS—1918

AMHERST COLLEGE
BARNARD COLLEGE
BRYN MAWR COLLEGE
CARLETON COLLEGE
COLUMBIA UNIVERSITY
CORNELL UNIVERSITY MEDICAL COLLEGE
CREIGHTON UNIVERSITY
DARTMOUTH COLLEGE
ELSE SERINGHAUS SCHOLARSHIP, HUNTER COLLEGE, NEW YORK CITY
GOUCHER COLLEGE
HARVARD UNIVERSITY
HARVARD UNIVERSITY MEDICAL SCHOOL
JOHNS HOPKINS UNIVERSITY
KANSAS STATE AGRICULTURAL COLLEGE
LAKE FOREST COLLEGE
MOUNT HOLYOKE COLLEGE
OBERLIN COLLEGE
PRINCETON UNIVERSITY
RADCLIFFE COLLEGE
RICE INSTITUTE
ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH
SMITH COLLEGE
SOPHIE NEWCOMB COLLEGE
UNIVERSITY OF CHICAGO
UNIVERSITY OF ILLINOIS
UNIVERSITY OF KANSAS
UNIVERSITY OF MICHIGAN
UNIVERSITY OF PENNSYLVANIA
UNIVERSITY OF WISCONSIN
VASSAR COLLEGE
WHEATON COLLEGE
WISTAR INSTITUTE OF ANATOMY AND BIOLOGY
YALE UNIVERSITY

SCHOLARSHIP TABLES

LUCRETIA CROCKER SCHOLARSHIPS FOR TEACHERS IN BOSTON
SCHOLARSHIP OF $100, SUPPORTED BY A FRIEND OF THE LABORATORY SINCE 1898.

5. EVENING LECTURES, 1918

Friday, July 5,
PROF. E. M. EAST....."The Phenomenon of Self-Sterility."
Tuesday, July 9,
PROF. W. J. V. OSTERHOUT .."Photosynthesis."
Friday, July 12,
PROF. JACQUES LOEB....."Why Does Mutilation of an Organism Induce Regeneration?"
Tuesday, July 16,
DR. S. O. MAST....."Problems, Methods and Results in Behavior."
Friday, July 19,
PROF. T. H. MORGAN....."Secondary Sexual Characters, Sex-linked Characters and Gynandromorphs."
Tuesday, July 23.
DR. JULES DUESBERG....."Mitochondria."
Friday, July 26,
DR. R. S. LILLIE....."Nature of Protoplasmic Transmission."
Tuesday, July 30,
DR. ROY W. MINER....."From Tidal Zone to Museum."
Friday, Aug. 2,
DR. GARY N. CALKINS....."*Uroleptus mobilis* and the Problem of Conjugation."
Tuesday, Aug. 6,
PROF. W. M. WHEELER....."The Life History and Behavior of the Worm-lion."
Friday, Aug. 9,
DR. J. ARTHUR HARRIS....."Mathematics in Biology."
Tuesday, Aug. 13,
PROF. Ross G. HARRISON...."Experiments on the Development of Limbs."

6. MEMBERS OF THE CORPORATION

LIFE MEMBERS

ALLIS, MR. E. P., JR., Palais Carnoles, Menton, France.
ANDREWS, MRS. GWENDOLEN FOULKE, Baltimore, Md.
BILLINGS, MR. R. C., 66 Franklin St., Boston, Mass.

CAREY, MR. ARTHUR ASTOR, Fayerweather St., Boston, Mass.
CLARKE, PROF. S. F., Williamstown, Mass.
CONKLIN, PROF. EDWIN G., Princeton University, Princeton, N. J.
CRANE, MR. C. R., Woods Hole, Mass.
DAVIS, MAJOR HENRY M., Syracuse, N. Y.
EVANS, MRS. GLENDOWER, 12 Otis Place, Boston, Mass.
FARLOW, Prof. W. G., Harvard University, Cambridge, Mass.
FAY, MISS S. B., 88 Mt. Vernon St., Boston, Mass.
FOLSOM, MISS AMY, 88 Marlboro St., Boston, Mass.
FOOT, MISS KATHERINE, 955 Park Ave., New York City, N. Y.
GARDINER, MRS. E. G., Woods Hole, Mass.
GARDINER, MISS EUGENIA, 15 W. Cedar St., Boston, Mass.
HARRISON, EX-PROVOST C. C., University of Pennsylvania, Philadelphia, Pa.
JACKSON, MISS M. C., 88 Marlboro St., Boston, Mass.
JACKSON, MR. CHAS. C., 24 Congress St., Boston, Mass.
KENNEDY, MR. GEO. G., 284 Warren St., Roxbury, Mass.
KIDDER, MR. C. G., 27 William St., New York City, N. Y.
KIDDER, MR. NATHANIEL T., Milton, Mass.
KING, MR. CHAS. A.
LEE, MRS. FREDERIC S., 279 Madison Ave., New York City, N. Y.
LOWELL, MR. A. LAWRENCE, 17 Quincy St., Cambridge, Mass.
MARRS, MRS. LAURA NORCROSS, 9 Commonwealth Ave., Boston, Mass.
MASON, MISS E. F., 1 Walnut St., Boston, Mass.
MASON, MISS IDA M., 1 Walnut St., Boston, Mass.
MEANS, MR. JAMES HOWARD, 196 Beacon St., Boston, Mass.
MERRIMAN, MRS. DANIEL, 73 Bay State Road, Boston, Mass.
MINNS, MISS SUSAN, 14 Louisburg Square, Boston, Mass.
MINNS, MR. THOMAS, 14 Louisburg Square, Boston, Mass.
MORGAN, MR. J. PIERPONT, JR., Wall and Broad Sts., New York City, N. Y.
MORGAN, PROF. T. H., Columbia University, New York City, N. Y.
MORGAN, MRS. T. H., New York City, N. Y.
NOYES, MISS EVA J.

NUNN, MR. LUCIAN L., Telluride, Colo.
OSBORN, PROF. HENRY F., American Museum of Natural History, New York City, N. Y.
PHILLIPS, DR. JOHN C., Windy Knob, Wenham, Mass.
PHILLIPS, MRS. JOHN C., Windy Knob, Wenham, Mass.
PORTER, DR. H. C., University of Pennsylvania, Philadelphia, Pa.
PULSIFER, MR. W. H., Newton Center, Mass.
ROGERS, MISS A. P., 5 Joy St., Boston, Mass.
SEARS, DR. HENRY F., 86 Beacon St., Boston, Mass.
SHEDD, MR. E. A.
SMITH, MRS. C. C., 286 Marlboro St., Boston, Mass.
THORNDIKE, DR. EDWARD L., Teachers College, Columbia University, New York City, N. Y.
TRELEASE, PROF. WILLIAM, University of Illinois, Urbana, Ill.
WARE, MISS MARY L., 41 Brimmer St., Boston, Mass.
WHITNEY, MR. HENRY M., Brookline, Mass.
WILCOX, MISS MARY A., Wellesley College, Wellesley, Mass.
WILMARTH, MRS. H. D., Elliott St., Jamaica Plain, Mass.
WILLIAMS, MRS. ANNA P., 505 Beacon St., Boston, Mass.
WILSON, DR. E. B., Columbia University, New York City, N. Y.
WILSON, PROF. W. P., Commercial Museum, Philadelphia, Pa.

7. CORPORATION MEMBERSHIP LIST

AUGUST, 1918

ABBOTT, PROF. J. F., Washington University, St. Louis, Mo.
ADDISON, DR. W. H. F., University of Pennsylvania Medical School, Philadelphia, Pa.
ADAMS, MISS A. E., Mount Holyoke College, South Hadley, Mass.
AGERSBORG, Dr. H. P. K., College of the City of New York, New York City, N. Y.
ALLEE, DR. W. C., Lake Forest College, Lake Forest, Ill.
ALLEN, PROF. EZRA, 125 Thompson Ave., Ardmore, Pa.
ALLYN, MISS HARRIET M., Hackett Medical College, Canton, China.

ALSBERG, DR. C. S., U. S. Dept. of Agriculture, Washington, D. C.
ALTENBURG, DR. EDGAR, Rice Institute, Houston, Texas.

BAITSELL, DR. GEORGE A., Yale University, New Haven, Conn.
BAKER, MRS. L. D., 123 Chiswick Road, Boston, Mass.
BAKER, DR. E. H., American Institute of Science, Chicago, Ill.
BANCROFT, PROF. F. W., Aloha Farm, Concord, Calif.
BECKWITH, MISS CORA J., Vassar College, Poughkeepsie, N. Y.
BEHRE, MISS ELINOR H., Carnegie Institution of Washington, Cold Spring Harbor, Long Island.
BEYER, DR. H. G., The Marlborough, Washington, D. C.
BIGELOW, PROF. M. A., Teachers College, Columbia University, New York City.
BIGELOW, PROF. R. P., Mass. Institute of Technology, Cambridge, Mass.
BINFORD, DR. RAYMOND, Earlham College, Richmond, Ind.
BORING, MISS ALICE M., Union Medical College, Peking, China.
BOX, MISS CORA MAY, University of Cincinnati, Cincinnati, Ohio.
BRADLEY, DR. HAROLD C., University of Wisconsin, Madison, Wis.
BRUMFIEL, DR. DANIEL M., University of Iowa, Iowa City, Iowa.
BUCKINGHAM, MISS EDITH N., 342 Marlboro St., Boston, Mass.
BUDINGTON, PROF. R. A., Oberlin College, Oberlin, Ohio.
BUMPUS, PROF. H. C., Tufts College, Tufts College, Mass.
BYRNES, DR. ESTHER F., 193 Jefferson Ave., Brooklyn, N. Y.

CALKINS, PROF. GARY N., Columbia University, New York City, N. Y.
CALVERT, PROF. PHILIP P., University of Pennsylvania, Philadelphia, Pa.
CARLSON, PROF. A. J., University of Chicago, Chicago, Ill.
CAROTHERS, MISS ELEANOR E., University of Pennsylvania, Philadelphia, Pa.
CARVER, PROF. GAIL L., Mercer University, Macon, Ga.
CARY, DR. L. R., Princeton University, Princeton, N. J.

CASTEEL, DR. D. B., University of Texas, Austin, Texas.
CATTELL, PROF. J. MCKEEN, Garrison-on-Hudson, N. Y.
CATTELL, MR. MCKEEN, Garrison-on-Hudson, N. Y.
CHAMBERS, DR. ROBERT, JR., Cornell University Medical College, New York City, N. Y.
CHESTER, PROF. WEBSTER, Colby College, Waterville, Maine.
CHIDESTER, PROF. F. E., Rutgers College, New Brunswick, N. J.
CHILD, PROF. C. M., University of Chicago, Chicago, Ill.
CLAPP, PROF. CORNELIA M., Mount Holyoke College, South Hadley, Mass.
CLARK, PROF. E. R., University of Missouri' Columbia, Mo.
CLOWES, DR. G. H. A., State Cancer Laboratory, Buffalo, N. Y.
COE, PROF. W. R., Yale University, New Haven, Conn.
COHN, DR. EDWIN J., 26 Walker St., Cambridge, Mass.
COLE, Dr. LEON J., College of Agriculture, Madison, Wis.
COLLEY, DR. R. H., Dartmouth College, Hanover, N. H.
COLTON, PROF. H. S., Ardmore, Pa.
COOLIDGE, MR. C. A., Ames Building, Boston, Mass.
COPELAND, PROF. MANTON, Bowdoin College, Brunswick, Maine.
COUTANT, MRS. MARY W., 1058A Sterling Place, Brooklyn, N. Y.
COWDRY, DR. E. V., Union Medical College, Peking, China.
CRAMPTON, PROF. H. E., Barnard College, Columbia University, New York City, N. Y.
CRANE, MRS. C. R., Woods Hole, Mass.
CURTIS, PROF. W. C., University of Missouri, Columbia, Mo.

DANCHAKOFF, MME. VERA, College of Physicians and Surgeons, New York City, N. Y.
DAVIS, MR. DONALD W., College of William and Mary, Williamsburg, Va.
DAVIS, PROF. BRADLEY M., University of Pennsylvania, Philadelphia, Pa.
DERICK, PROF. CARRIE M., McGill University, Montreal, Canada.
DEXTER, DR. J. S., University of Saskatchewan, Saskatoon, Saskatchewan.
DODDS, PROF. G. S., Medical School, University of West Virginia, Morgantown, W. Va.

DONALDSON, PROF. H. H., Wistar Institute of Anatomy and Biology, Philadelphia, Pa.
DONALDSON, DR. JOHN C., University of Cincinnati, Cincinnati, Ohio.
DREW, PROF. GILMAN A., Marine Biological Laboratory, Woods Hole, Mass.
DUGGAR, PROF. B. M., Missouri Botanical Garden, St. Louis, Mo.
DUNGAY, DR. NEIL S., Carleton College, Northfield, Minn.
DUNN, DR. ELIZABETH, Woods Hole, Mass.

EDWARDS, DR. D. J., Cornell University Medical College, New York City.
EIGENMANN, PROF. C. H., University of Indiana, Bloomington, Ind.
ELLIS, DR. F. W., Monson, Mass.

FARNUM, MISS LOUISE W., 43 Hillhouse Ave., New Haven, Conn.
FIELD, MISS HAZEL E., Sophie Newcomb College, New Orleans, La.
FIELD, PROF. IRVING, 1 Autumn St., Worcester, Mass.
FISH, MR. J. BURTON, Boys' High School, Brooklyn, N. Y.

GAGE, PROF. S. H., Cornell University, Ithaca, N. Y.
GARREY, PROF. W. E., Tulane University, Richardson Memorial, New Orleans.
GIES, PROF. W. J., Columbia Univ. Dept. Physiological Chemistry, New York City, N. Y.
GLASER, PROF. O. C., Amherst College, Amherst, Mass.
GLASER, DR. R. W., Bussey Institution, Forest Hills, Mass.
GOLDFARB, PROF. A. J., College of the City of New York, New York City.
GOODRICH, MR. H. B., Wesleyan University, Middletown, Conn.
GRAVE, DR. CASWELL, Johns Hopkins University, Baltimore, Md.
GREGORY, DR. LOUISE H., Barnard College, Columbia University, New York City.
GREGORY, DR. EMILY R., Sweet Briar College, Sweet Briar, Va.
GREENMAN, PROF. M. J., Wistar Institute of Anatomy and Biology, Philadelphia, Pa.

GROSS, MISS BEATRIX H., 457 Convent Ave., New York City.
GUNTHER, MISS MAUDE C., Business High School, Washington, D. C.
GUYER, PROF. M. F., University of Wisconsin, Madison, Wis.

HAHN, DR. C. W., 18 Murray St., Murray Hill, Flushing, N. Y.
HANCE, MR. ROBERT T., University of Pennsylvania, Philadelphia, Pa.
HARGITT, PROF. C. W., Syracuse University, Syracuse, N. Y.
HARMAN, DR. MARY T., Kansas State Agricultural College, Manhattan, Kansas.
HARPER, PROF. R. A., Columbia University, New York City, N. Y.
HARRISON, MR. A. C., 660 Drexel Bldg., 5th and Chestnut Sts., Philadelphia.
HARRISON, PROF. ROSS G., Yale University, New Haven, Conn.
HARVEY, PROF. B. C. H., University of Chicago, Chicago, Ill.
HARVEY, DR. E. N., Princeton University, Princeton, N. J.
HARVEY, MRS. E. N., Princeton, N. J.
HAYDEN, MISS MARGARET A., Wellesley College, Wellesley, Mass.
HEATH, PROF. HAROLD, Stanford University, Calif.
HEGNER, PROF. R. W., Johns Hopkins University, Baltimore, Md.
HEILBRUNN, MR. L. V., University of Illinois College of Medicine, Chicago.
HOAR, MR. D. BLAKELY, 161 Devonshire St., Boston, Mass.
HOGUE, DR. MARY J., Wellesley College, Wellesley, Mass.
HOLMES, PROF. S. J., University of California, Berkeley, Calif.
HOSKINS, MRS. ELMER R., 53 Edgehill Road, New Haven, Conn.
HOYT, DR. WILLIAM D., Washington and Lee University, Lexington, Va.
HYDE, DR. IDA H., State University of Kansas, Lawrence, Kansas.

JACKSON, PROF. C. M., University of Minnesota, Minneapolis, Minn.
JACOBS, PROF. MERKEL H., University of Pennsylvania, Philadelphia, Pa.

JENNINGS, PROF. H. S., Johns Hopkins University, Baltimore, Md.
JENNER, PROF. E. A., Simpson College, Indianola, Iowa.
JEWETT, PROF. J. R., Harvard University, Cambridge, Mass.
JONES, PROF. LYNDS, Oberlin College, Oberlin, Ohio.
JORDAN, PROF. H. E., University of Virginia, University, Va.
JUST, PROF. E. E., Howard University, Washington, D. C.

KANDA, DR. SAKYO, Physiological Laboratory, Kyushu Imperial University, Fukuoka, Japan.
KELLICOTT, PROF. W. E., College of the City of New York, New York City.
KENNEDY, DR. HARRIS, Readville, Mass.
KINDRED, MR. J. E., Western Reserve University, Dental School, Cleveland.
KING, DR. HELEN D., Wistar Institute of Anatomy and Biology, Philadelphia.
KINGSBURY, Prof. B. F., Cornell University, Ithaca, N. Y.
KINGSLEY, PROF. J. S., University of Illinois, Urbana, Ill.
KIRKHAM, DR. W. B., Yale University, New Haven, Conn.
KNOWER, PROF. H. MCE., University of Cincinnati, Cincinnati, Ohio.
KNOWLTON, PROF. F. P., Syracuse University, Syracuse, N. Y.
KOSTIR, MR. W. J., Ohio State University, Columbus, Ohio.
KRIBS, DR. HERBERT, University of Pennsylvania, Philadelphia, Pa.

LANE, PROF. HENRY H., State University of Oklahoma, Norman, Okla.
LEE, PROF. F. S., 437 West 59th St., New York City, N. Y.
LEFEVRE, PROF. GEORGE, University of Missouri, Columbia, Mo.
LEWIS, PROF. I. F., University of Virginia, University, Va.
LEWIS, PROF. W. H., Johns Hopkins University, Baltimore, Md.
LILLIE, PROF. FRANK R., University of Chicago, Chicago, Ill.
LILLIE, PROF. R. S., Clark University, Worcester, Mass.
LINTON, PROF. EDWIN, Washington and Jefferson College, Washington, Pa.
LOEB, PROF. JACQUES, Rockefeller Institute for Medical Research, New York City, N. Y.

LOEB, PROF. LEO, Washington University Medical School, St. Louis, Mo.

LOWTHER, MRS. FLORENCE DEL., Barnard College, Columbia University, New York City, N. Y.

LUND, DR. E. J., University of Minnesota, Minneapolis, Minn.

LUSCOMBE, MR. W. O., Woods Hole, Mass.

LYMAN, PROF. GEORGE R., Federal Horticultural Board, Washington, D. C.

LYNCH, MISS CLARA J., 141 East 44th St., New York City.

LYON, PROF. E. P., University of Minnesota, Minneapolis, Minn.

MACCALLUM, DR. G. A., 981 Madison Ave., New York City, N. Y.

MCCLUNG, PROF. C. E., University of Pennsylvania, Philadelphia, Pa.

MCGEE, DR. A. N., 1620 P St., Washington, D. C.

MCGILL, DR. CAROLINE, Murray Hospital, Butte, Montana.

MCGREGOR, DR. J. H., Columbia University, New York City, N. Y.

MCINDOO, DR. N. E., Bureau of Entomology, Washington, D. C.

MCMURRICH, PROF. J. P., University of Toronto, Toronto, Canada.

MACKLIN, DR. CHARLES C., School of Medicine, University of Pittsburgh, Pittsburgh, Pa.

MAHR, MR. ERNEST F., University of Chicago, Chicago, Ill.

MALONE, PROF. E. F., University of Cincinnati, Cincinnati, Ohio.

MARTIN, MISS BERTHA E., Wheaton College, Norton, Mass.

MARQUETTE, DR. WILLIAM, Columbia University, New York City, N. Y.

MATHEWS, PROF. A. P., University of Cincinnati, Cincinnati, Ohio.

MAYOR, PROF. A. G., Maplewood, N. J.

MEIGS, DR. E. B., Dairy Division Experiment Station, Beltsville, Md.

MEIGS, MRS. E. B., 1445 Rhode Island Ave., Washington, D. C.

MELTZER, DR. S. J., 13 West 121st St., New York City, N. Y.

METCALF, PROF. M. M., 128 Forest St., Oberlin, Ohio.

MINER, DR. ROY W., American Museum of Natural History, New York City.
MINOR, MISS MARIE L., Women's University Club, New York City, N. Y.
MINOURA, MR. TADACHIKA, University of Chicago, Chicago, Ill.
MITCHELL, DR. PHILIP H., Brown University, Providence, R. I.
MOORE, PROF. GEORGE T., Missouri Botanical Garden, St. Louis, Mo.
MOORE, DR. CARL R., University of Chicago, Chicago, Ill.
MOORE, PROF. J. PERCY, University of Pennsylvania, Philadelphia, Pa.
MOORE, DR. A. R., Rutgers College, New Brunswick, N. J.
MOORE, MISS DOROTHEA M., 21 Kirkland St., Cambridge, Mass.
MORGAN, PROF. H. A., Agricultural Experiment Station, Knoxville, Tenn.
MORGAN, DR. ANNA H., Mount Holyoke College, South Hadley, Mass.
MORRILL, PROF. A. D., Hamilton College, Clinton, N. Y.
MORRILL, DR. C. V., Cornell University Medical College, New York City.
MULLER, DR. H. J., Columbia University, New York City, N. Y.
MURBACH, DR. LOUIS, Central High School, Detroit, Mich.

NABOURS, DR. R. K., Kansas State Agricultural College, Manhattan, Kansas.
NACHTRIEB, PROF. HENRY F., University of Minnesota, Minneapolis, Minn.
NEAL, PROF. H. V., Tufts College, Tufts College, Mass.
NEWMAN, PROF. H. H., University of Chicago, Chicago, Ill.
NICHOLS, DR. M. LOUISE, 3221 Race St., Philadelphia, Pa.

OSBURN, PROF. R. C., Ohio State University, Columbus, Ohio.
OSTERHOUT, PROF. W. J. V., Harvard University, Cambridge, Mass.

PACKARD, DR. CHARLES, Union Medical College, Peking, China.
PACKARD, DR. W. H., Bradley Polytechnic Institute, Peoria, Ill.
PAINTER, DR. T. S., University of Texas, Austin, Texas.

PAPPENHEIMER, DR. A. M., Columbia University, New York City, N. Y.
PARKER, PROF. G. H., Harvard University, Cambridge, Mass.
PATON, PROF. STEWART, Princeton University, Princeton, N. J.
PATTEN, PROF. WILLIAM, Dartmouth College, Hanover, N. H.
PATTERSON, PROF. J. T., University of Texas, Austin, Texas.
PAYNE, PROF. F., University of Indiana, Bloomington, Ind.
PEARSE, PROF. A. S., University of Wisconsin, Madison, Wis.
PEEBLES, MISS FLORENCE, Bryn Mawr College, Bryn Mawr, Pa.
PHILLIPS, MISS RUTH L., Western College, Oxford, Ohio.
PIKE, PROF. FRANK H., 437 West 59th St., New York City, N. Y.
PINNEY, MISS MARY E., 10 Leighton Road, Wellesley, Mass.
PORTER, MRS. M. B., 402 West 30th St., Austin, Texas.
PRENTISS, MISS HENRIETTA, Normal College, New York City, N. Y.
PRICE, DR. WESTON A., Research Commission of the National Dental Association, Cleveland, Ohio.

RAE, MISS ANNE M., 34 Jefferson Ave., Brooklyn, N. Y.
RANKIN, PROF. W. M., Princeton University, Princeton, N. J.
REA, DR. PAUL M., Charleston Museum, Charleston, S. C.
REDFIELD, DR. ALFRED C., Harvard Medical School, Boston, Mass.
REIGHARD, PROF. JACOB, University of Michigan, Ann Arbor, Mich.
REINKE, DR. E. E., Vanderbilt University, Nashville, Tenn.
RICE, PROF. EDWARD L., Ohio Wesleyan University, Delaware, Ohio.
RICHARDS, DR. A., Wabash College, Crawfordsville, Ind.
RICHARDS, MRS. A., 807 E. Jefferson St., Crawfordsville, Ind.
ROBERTSON, MISS ALICE, 334 17th Avenue, Seattle, Wash.
ROBERTSON, PROF. W. R. B., University of Kansas, Lawrence, Kansas.
ROGERS, PROF. CHARLES G., Oberlin College, Oberlin, Ohio.
ROSENOW, DR. E. C., Mayos Clinics, Rochester, Minn.
RUDISCH, DR. J., Mount Sinai Hospital, New York City, N. Y.

SANDS, MISS ADELAIDE G., 348 N. Main St., Port Chester, N. Y.
SANDS, DR. GEORGIANA, 348 N. Main St., Port Chester, N. Y.

SCOTT, DR. ERNEST L., Columbia University, New York City, N. Y.

SCOTT, PROF. G. G., College of the City of New York, New York City, N. Y.

SCOTT, PROF. JOHN W., University of Wyoming, Laramie, Wyoming.

SHULL, PROF. A. FRANKLIN, University of Michigan, Ann Arbor, Mich.

SHUMWAY, MR. WALDO, Amherst College, Amherst, Mass.

SMITH, DR. BERTRAM G., State Normal College, Ypsilanti, Michigan.

SNOW, MISS LAETITIA M., Wellesley College, Wellesley, Mass.

SOLLMAN, DR. TORALD, Western Reserve University, Cleveland, Ohio.

SPAETH, DR. REYNOLD A., School of Public Health, Johns Hopkins University, Baltimore, Md.

SPENCER, PROF. H. J., 123 Waverly Place, New York City, N. Y.

SPROWLES, MISS EDITH A., 4833 Griscom St., Frankford, Pa.

STOCKARD, PROF. C. R., Cornell University Medical College, New York City.

STOKEY, DR. ALMA G., Mount Holyoke College, South Hadley, Mass.

STREETER, PROF. GEORGE L., Johns Hopkins University Medical School, Baltimore, Md.

STRONG, PROF. O. S., Columbia University, New York City, N. Y.

STRONG, PROF. R. M., Chicago College of Medicine and Surgery, Chicago, Ill.

STURTEVANT, DR. ALFRED, H., 528 West 123d St., New York City, N. Y.

TASHIRO, DR. SHIRO, University of Chicago, Chicago, Ill.

TAYLOR, MISS KATHERINE A., Cascade, Washington Co., Md.

TENNENT, PROF. D. H., Bryn Mawr College, Bryn Mawr, Pa.

THOMAS, DR. ADRIAN, 2012 Hanover Ave., Richmond, Va.

THOMPSON, PROF. CAROLINE B., 9 Leighton Road, Wellesley, Mass.

TINKHAM, MISS FLORENCE L., 71 Ingersoll Grove, Springfield, Mass.

TOMPKINS, MISS ELIZABETH M., 134 Linden Ave., Brooklyn, N. Y.

TREADWELL, PROF. A. L., Vassar College, Poughkeepsie, N. Y.

TURNER, DR. C. L., Marquette Univ. School of Medicine, Milwaukee, Wis.

UHLENHUTH, DR. EDWARD, Rockefeller Institute for Medical Research, New York City, N. Y.

WAITE, PROF. F. C., Western Reserve University Medical School, Cleveland, Ohio.

WARBASSE, MRS. J. P., 384 Washington Ave., Brooklyn, N. Y.

WARD, PROF. H. B., University of Illinois, Urbana, Ill.

WARDWELL, DR. E. H., Mattapoisett, Mass.

WARREN, PROF. HOWARD C., Princeton University, Princeton, N. J.

WASTENEYS, DR. HARDOLPH, University of California, Berkeley, Calif.

WATSON, DR. FRANK E., HOBART College, Geneva, N. Y.

WENRICH, DR. D. H., University of Pennsylvania, Philadelphia, Pa.

WERBER, DR. E. I., Yale University, New Haven, Conn.

WHEELER, PROF. W. M., Bussey Institution, Forest Hills, Mass.

WHERRY, DR. W. B., Cincinnati Hospital, Cincinnati, Ohio.

WHITE, MISS E. GRACE, Heidelberg University, Tiffin, Ohio.

WHITNEY, DR. DAVID D., University of Nebraska, Lincoln, Neb.

WHITING, MR. PHINEAS W., 834 Marietta Ave., Lancaster, Pa.

WIEMAN, PROF. H. L., University of Cincinnati, Cincinnati, Ohio.

WILCOX, DR. ALICE W., 417 West 120th St., New York City, N. Y.

WILDMAN, DR. E. E., 47th and Walnut Sts., Philadelphia, Pa.

WILLIAMS, DR. ANNA W., 549 Riverside Drive, New York City, N. Y.

WILSON, PROF. H. V., University of North Carolina, Chapel Hill, N. C.

WOGLOM, DR. WILLIAM H., Columbia University, New York City, N. Y.

WOODRUFF, PROF. L. L., Yale University, New Haven, Conn.
WOODWARD, MISS ALVALYN E., Simmons College, Boston, Mass.

YOUNG, MR. D. B., North Hanover, Mass.
YOUNG, PROF. ROBERT T., University of North Dakota, University, N. D.